(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 320 397 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
23.05.2012 Bulletin 2012/21

(51) Int Cl.:
G08B 17/10 *(2006.01)* *G08B 29/18* *(2006.01)*

(21) Application number: **09174290.8**

(22) Date of filing: **28.10.2009**

(54) **Fire sensor and method for detecting fire**

Brandsensor und Verfahren zur Erkennung von Bränden

Capteur d'incendie et procédé de détection de feu

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(43) Date of publication of application:
11.05.2011 Bulletin 2011/19

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EP 2 320 397 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] This invention relates to fire sensors, fire detection systems and methods of detecting fire. The disclosed technique is particularly suitable for use in low-profile fire sensors but can also be applied to other types of sensor unit.

[0002] Low-profile fire alarm detectors are becoming increasingly used where an architect requires good aesthetics and a clean line to the ceiling area in a monitored region. In general, low-profile detectors are recessed into the ceiling or other surface such that the completed units sits essentially flush with the remainder of the ceiling. Hence, possible future applications of this type of detector include uses where fire detection is required in prison-type accommodation without adding ligature points.

[0003] Such low-profile detectors typically make use of an open optical scatter chamber for detection of fire. Essentially this comprises a radiation emitter and a corresponding detector spaced from one another on a ceiling plate. The radiation emitter produces a beam of radiation at an acute angle to the plate such that the detector is not directly illuminated. In the event of fire, fire products such as smoke and other aerosols (such as water vapour, chemicals and possibly oils) rise towards the detector and intercept the radiation beam causing scattering which is received by the detector. An alarm may be triggered if the amount of radiation received by the detector exceeds a certain threshold. An example of an open optical scatter chamber of this sort is disclosed in US-A-6,515,589.

[0004] However, the use of an open chamber using the optical scatter principle presents a major problem for fire detection, since despite sophisticated countermeasures, faults or false alarms tend to be common (compared to fire sensors with closed detection chambers), resulting from ambient light falling on the detector, or the possibility of steam, insects or any floating objects triggering the detector, since there is unrestricted access to the detection region. In particular, it is extremely difficult to achieve a high sensitivity sensor using this approach with an acceptably low false alarm rate. In practice, it is necessary to provide such sensors with measures for distinguishing between true fire products and other objects. For example, US-A-6,515,589 discloses a number of approaches, including increasing the effective detector area such that the detector will only be partially illuminated by scatter from a discrete object such as an insect, but fully illuminated by smoke. An alternative technique involves analysing the time over which the signal occurs. Whilst such measures provide some improvement, the occurrence of future alarms is still more frequent than for conventional sensors having closed detection chambers. Also, where used in a prison setting for example, such measures could feasibly be bypassed and malicious false alarms repeatedly generated.

[0005] An additional problem found with the use of open chamber sensors is that fire detection standards generally require smoke detectors to include ingress protection, i.e. a chamber cover with restricted access, to prevent objects entering the detection chamber. As such, these standards make no provision for open chamber sensors which have no such ingress protection. Approval to special standards is possible but usually requires the provision of two detectors in each protected area and also limiting the use of such sensors to markets where the special standard would be accepted.

[0006] An alternative to the use of open chamber detectors, which also allows for low-profile aesthetics, is the use of an aspirating smoke detector (ASD). This comprises a series of pipes, often concealed behind ceiling panels, with one or more sampling points through which air from the monitored region is drawn back to a remote fan box which filters the air and passes it over one or more smoke sensors. Exhaust air is returned back to the protected area using a return pipe, or is alternatively vented outside. This system can be relatively cost and power efficient if the pipes have many sampling points to thereby cover a large protection area. However, having lots of sampling points makes identifying the position at which the fire started very difficult. In addition, the smoke sensors used must be extremely sensitive, since any fire products will be significantly diluted between the monitored region and the remote fan box. Finally, ASD's are also limited to sensing fire via the detection of smoke, since the dilution makes gas and heat detection unreliable. In some cases, a number of ASD's, each one having a single sampling point, can be used where the location of a fire needs to be pinpointed reliably.

[0007] JP-A-2001-080592 and US-A-4,785,288 disclose variations of the ASD concept implemented in a point sensor in which a smoke detector is provided with a fan to draw air continuously across the smoke detector. However, such arrangements are only suitable for a limited number of applications where plenty of power is available for a small number of sensor devices. Also, such configurations suffer from permanent fan noise which may not be acceptable in residential environments, and from the requirement for frequent maintenance of the fan.

[0008] In accordance with the present invention, a fire sensor is provided for detecting fire in a monitored region, the fire sensor comprising: a chamber in fluid communication with the monitored region via at least one inlet; an internal detector assembly adapted to detect fire products within the chamber and to output a corresponding internal detection signal; an external detector assembly adapted to detect fire products outside the chamber in the monitored region and to output a corresponding external detection signal; a fluid transport device adapted to draw a sample of the atmosphere from the monitored region into the chamber through the at least one inlet; and a controller adapted to activate the fluid transport device upon receipt of a trigger signal based on the external detection signal to thereby draw a sample of the atmosphere from the monitored region into the chamber for analysis by the internal detector assembly.

[0009] By using an external detector assembly to trigger the flow of air (fluid) from the monitored region into an internal chamber where high precision analysis can take place, a number of significant advantages are achieved. Firstly, since a fan or other device for actively drawing air into the detection chamber is provided, the chamber can be recessed into the ceiling of the monitored region, permitting a low-profile aesthetic. Conventional detection chambers, in contrast, must be arranged to protrude some distance below the ceiling in order to cross the stagnant boundary layer that exists adjacent to the ceiling. The provision of a fan ensures that fire products are collected at ceiling height despite the boundary layer, and also causes fire products to build up quickly within the chamber such that any fire is quickly and accurately sensed.

[0010] Significantly, by arranging external detectors to sense conditions in the monitored environment, and triggering the fan upon detection of a suspected fire, the fan need not be continuously powered. Rather, the atmosphere is only sampled when there is an indication of fire from the external detectors. This greatly reduces the amount of power used and massively extends the lifetime of the fan as well as the maintenance period. In addition, the inlet (and outlet, if provided, since this is an additional ingress point) to the chamber can be provided with conventional ingress protection means, such as a mesh or filter or other restrictive barrier, thereby meeting certification requirements. This would not usually be possible in the case of a fan-assisted point sensor, since the continual flow of air through the filter would result in it becoming clogged at regular intervals. However, in the present arrangement, since the air flow into the chamber is event triggered, the possibility of the mesh becoming blocked by debris is effectively no more significant than for a conventional internal detection chamber sensor without a fan.

[0011] Ultimately, the possibility of false alarms is substantially reduced compared with the open chamber optical scatter approach, since air from the monitored region is subjected to testing in an internal detection chamber which is inherently protected from influences such as ambient light, insects, etc. The likelihood of false alarms is therefore at least as low as for conventional internal detection chambers and, indeed, it is further reduced since an alarm will only be generated if both the external and internal detectors sense fire products.

[0012] The fire products which may be detected by the fire sensor encompass any detectable fire phenomena. For example, common fire products that may be detected include smoke, other aerosols, gases produced by combustion such as carbon monoxide, carbon dioxide, hydrogen and oxides of nitrogen (NO_x), heat, flames and thermal radiation (e.g. infrared). Each of the internal detector assembly and external detector assembly may be arranged to detect any one or more such fire products, and those detected by the internal assembly need not be the same as those detected by the external assembly.

[0013] Processing of the signals output by the internal and external detector assemblies may be carried out onboard the fire sensor or could alternatively be performed at a remote processor comprised in a control panel, for example, or any combination of the two. In these latter cases, the fire sensor would include appropriate communication ports for inputting and outputting data to the control panel. However, in a preferred example, the fire sensor further comprises a processor adapted to determine whether the external detection signal meets a predetermined trigger criterion and, if so, to generate the trigger signal. If desired, the processor could be integral with the controller. By conducting this processing onboard, the sensor can operate as a standalone unit. Alternatively, if used within a system, the reaction time is reduced since no remote processing is involved in the switching-on of the fan. The bandwidth consumption on the network is also reduced. The predetermined trigger criterion will depend on the nature of the external detector assembly. If a single sensor is used, the trigger signal may be generated upon the value of the sensor signal crossing a predetermined threshold, or entering or leaving a predefined range of values. Where more than one sensor is used to form the external detector assembly, the signals from each may be assessed in combination. In general, the predetermined trigger criterion corresponds to the onset of conditions in the monitored region which appear indicative of the presence of fire.

[0014] Advantageously, the fire sensor further comprises a processor adapted to evaluate whether the internal detection signal meets a predetermined alarm criterion, if so, to generate an alarm signal and (preferably) if not, to generate a deactivate signal whereby the controller deactivates the fluid transport device. Again, this processing could be carried out remotely if preferred. As already indicated, by using an internal detector assembly to ascertain whether fire conditions are met, the possibility of false of alarms is greatly reduced. The alarm signal may be output to a remote device such as a control panel or control centre (e.g. notifying the local Fire Service) and/or used to trigger an audible and/or visible alarm, such as a sounder, which may form part of the fire sensor or may be provided separately (e.g. on a networked device). By deactivating the fluid transport device if fire conditions are not detected, the lifetime of the fan is optimised. Alternatively, the controller could automatically deactivate the fan after a predetermined period of time.

[0015] As already indicated, any product of fire could be used as a basis for detection. As such, the internal detector assembly preferably comprises any of: an optical scatter sensor, comprising a radiation emitter arranged to emit a beam of radiation, and a radiation detector disposed off the beam path, the receipt of radiation at the detector being indicative of optical scatter caused by fire products intercepting the radiation beam; a dual angle optical scatter sensor comprising either a radiation emitter and at least two radiation detectors arranged to receive radiation scattered at different angles from one

another or a radiation detector and at least two radiation emitters arranged to emit beams at different angles to the detector; an optical obscuration sensor; a heat sensor; a gas sensor adapted to detect one or more gaseous fire products, preferably carbon monoxide, carbon dioxide, hydrogen or an oxide of nitrogen (NO_x); and/or an ionisation smoke sensor.

[0016] Likewise, numerous options are available for the external detector assembly, which preferably comprises any of: at least one optical scatter sensor, comprising a radiation emitter arranged to emit a beam of radiation at a predetermined angle from the fire sensor, and a radiation detector disposed off the beam path, the receipt of radiation at the detector being indicative of optical scatter caused by fire products intercepting the radiation beam; a gas sensor adapted to detect one or more gaseous fire products, preferably carbon monoxide, carbon dioxide, hydrogen or NO_x; a flame detector, comprising a radiation detector adapted to receive thermal radiation from within the monitored region at a predetermined wavelength range, and a processor adapted to detect flicker in the received radiation indicative of a flame; a heat sensor and/or an infrared radiation detector.

[0017] In a particularly preferred embodiment, the external detector assembly comprises first and second optical scatter sensors (each as defined above), the first optical scatter sensor being arranged to emit a radiation beam at a first predetermined angle and the second optical scatter sensor being arranged to emit a radiation beam at a second predetermined angle which is less than the first, such that the first optical scatter sensor is responsive to smoke products spaced further from the fire sensor compared to the second optical scatter sensor. The first and second optical scatter sensors may each operate at essentially the same wavelength or at different, spaced, wavelengths. By providing different scatter angles, the distance over which fire products will be detected is extended. In addition, the sensor can effectively track the transport of the fire product towards the ceiling, since the first optical scatter sensor will be triggered before the second. The provision of two scatter angles also makes it possible to adjust the sensitivity of the external detector assembly as appropriate for the ceiling height. For instance, in a very low ceiling areas, a large monitoring distance under the sensor would not be desirable and so the sensitivity of the first (high angle) optical scatter sensor may be reduced or even switched off to prevent tripping by activity within the room. In contrast, where the ceiling is very high there is greater risk of stratification occurring at some distance below the ceiling and hence the sensitivity of the first (high angle) scatter sensor could be increased in order to ensure detection occurs quickly.

[0018] Advantageously, the radiation emitter of the first or second optical scatter sensor is arranged to partially illuminate the radiation detector of the other optical scatter sensor such that a background level of radiation is detected in the absence of fire products. This background level provides confirmation that the external detector assembly is operational and has not been tampered with. For example, if the optical scatter sensor elements were to be painted over, the detector would register zero radiation. Thus, the external detection signal can be monitored and a fault signal generated should the detected levels fall below the expected background level. This processing could be carried out onboard the fire sensor or remotely.

[0019] The fluid transport system can take any form that is capable of drawing air and fire products from the monitored region into the chamber. In preferred examples, the fluid transport device comprises a fan, a pump or a vacuum.

[0020] Upon activation, the fan or other fluid transport device could be operated continuously for a period of time or until a deactivation signal is received. However, to reduce the power consumption and extend the lifetime of the fan, pulsed operation is preferred. Hence, advantageously, the controller is further adapted to intermittently activate the fluid transport device after receipt of a trigger signal or an alarm signal according to a predetermined duty cycle, preferably a low duty cycle of less than 50%, still preferably around 25%. Of course, such control could be provided remotely by a control panel or similar.

[0021] Preferably, after a trigger signal the fan is powered continuously until an alarm signal is generated or a predetermined period of time has elapsed without an alarm signal being generated. This ensures that any fire products present are drawn into the detection chamber quickly. Once an alarm signal is generated, the fan is preferably operated at the low duty cycle to reduce power consumption whilst providing information as to the development of the fire. In addition to, or instead of, this pulsed operation, the voltage supplied to the fan could be reduced so that it runs at a lower speed, to reduce power whilst still allowing fire monitoring. This allows for maximum power to be supplied to any alarm devices (e.g. sounders and strobes) used on the same power loop as the sensor.

[0022] The chamber could be vented externally (e.g. into a ceiling cavity or outside) or the collected sample could be allowed to return to the monitored region after deactivation of the fluid transport device, through the inlet. However, preferably, the chamber is provided with an outlet enabling the atmospheric sample to escape from the chamber to the monitored region, the outlet being disposed adjacent to the inlet such that circulation of the atmosphere adjacent the fire sensor within the monitored region is established when the fluid transport device is active. By outputting the collected air from the chamber back to the monitored region in this way, an air current is established which causes mixing of the atmosphere in the vicinity of the fire sensor further assisting in overcoming any stratification that has occurred, and ensuring that any fire products present will enter the detection chamber. Stratification occurs where hot air containing the fire products ceases to rise before reaching ceiling height and instead spreads out horizontally.

[0023] In particularly advantageous examples, the inlet comprises multiple inlet points surrounding the outlet, or the outlet comprises multiple outlet points surrounding the inlet (although this is less preferred), such that a substantially toroidal circulation path is established adjacent the fire sensor, the multiple inlet or outlet points preferably being arranged to form an annulus. This achieves particularly good mixing and ensures that fire products around and below the sensor can be sampled. It should be noted that each inlet / outlet "point" need not be defined by an individual aperture or pathway - for example a shaped aperture can provide multiple inlet/outlet points (positions) along its length.

[0024] The internal nature of the chamber inherently reduces the possibility of false alarms caused by objects intercepting external scatter angles. However, to further enhance this and to ensure that the sensor meets current standards, the fire sensor preferably further comprises a guard arranged to prevent the ingress of objects into the chamber, the guard preferably comprising a filter or mesh arranged across the inlet. A similar guard should additionally be provided across any outlet connecting the monitored region to the chamber.

[0025] Preferably, the fire sensor further comprises an airflow sensor adapted to detect the movement of fluid within the chamber or between the chamber and the monitored region and to output a corresponding airflow signal. Any form of airflow sensor capable of detecting movement of air could be used for this purpose. For example, a pair of thermistors of which one is heated and one remains at ambient temperature may be provided. Passage of air past the thermistors would cause the heated element to cool. The resulting change in relative temperature between the two elements provides a measure of the air flow. The temperature of the thermistors can be measured by monitoring the electrical resistance of each.

[0026] The airflow detector can be used to check that there is no obstruction of the inlet (or outlet), thereby confirming that the sensor is operating correctly. The signal from the airflow detector could be sampled upon receipt of a trigger signal (or a short delay thereafter) and used to confirm that the sensor is operating correctly in a potential alarm scenario. However, preferably, the fire sensor further comprises a processor adapted to output a test signal to the controller at intervals to thereby intermittently activate the fluid transport device, to determine whether the corresponding airflow signal meets predetermined obstruction conditions, and if so to output an obstruction signal. By activating the fan at regular intervals (irrespective of a trigger signal), early detection of airflow problems is possible. Hence, should an obstruction signal be output, the fire sensor can be serviced and the obstruction removed. Preferably, the sensor can switch to a fall-back mode whereby the processor is further adapted to, upon receipt of an obstruction signal, determine whether the external detection signal meets a predetermined open chamber alarm criterion different from the predetermined trigger criterion, and if so, to generate an alarm signal. In effect, whilst the obstruction is in place, the fire sensor acts as an open chamber detector. To reduce the possibility of false alarms, the criterion applied to the external detection signal for the identification of fire conditions is preferably less sensitive than the predetermined trigger criterion. That is, when operating in fall-back mode, the sensor will not generate an alarm signal upon occurrence of all the same conditions which would otherwise lead to the fan being triggered in normal operation: an alarm will only be generated where there is greater evidence of fire.

[0027] As previously indicated, the fire sensor is particularly suitable for use as a low-profile sensor. However, the application of the technique is not so limited since conventional high-profile sensors will also benefit. Nonetheless, in a particularly preferred embodiment, the fire sensor is adapted to be mounted to a surface, preferably a ceiling, of the monitored region, the fire sensor further comprising a substantially flat plate adapted to engage and lie substantially flush with the surface in use, and being disposed between the monitored region and the chamber.

[0028] In advantageous embodiments, the fire sensor further comprises a sounder, preferably a piezoelectric sounder. The sounder can be configured to output an alarm sound such as a buzzer or siren, or to output a voice message. The sounder can be controlled by an onboard controller or remotely. The fire sensor may alternatively or additionally comprise a strobe.

[0029] In another implementation, a fire sensor and loudspeaker assembly is provided, wherein the fire sensor is incorporated into the loudspeaker, or vice versa. The loudspeaker may be an addressable loudspeaker provided on a power/data loop of a fire detection system, controlled for example by the control panel. In this example, the fire sensor should be a low profile fire sensor having a flat exterior surface. However, whilst it is preferred that the fire sensor be configured as disclosed above, this is not essential and a conventional open chamber sensor could be used instead. Where a conventional loudspeaker having a sounder cone is used, the external detection assembly is preferably arranged adjacent the periphery of the cone's extremity on a peripheral rim of the unit. If an internal detection chamber, fan and internal sensors are provided, these are preferably situated behind or to a side of the sounder cone. Alternatively, a flat speaker could be incorporated into a ceiling plate (or other flat surface) of the fire sensor.

[0030] The present invention also provides a fire detection system, comprising at least one fire sensor as described above and a control panel arranged for communication with the or each fire sensor the control panel being adapted to monitor the status of the or each fire sensor. The control panel can take many forms, ranging from low functionality (e.g. simply identifying when any of the fire sensors reports an alarm signal) to advanced control functions, including some or all of the previously described onboard processing steps. The provision of a

control panel makes it possible to observe the status of several monitored regions (each corresponding to a respective fire sensor) at a single location. In preferred implementations, each of the fire sensors includes an address such that the control panel can identify the location of any alarm signals received. The control panel can be located close to one or more of the fire sensors (e.g. within the same building) or could be remotely located, for example at a control centre. Alternatively, a local control panel could include communications means for communicating with such a control centre. Communications between the control panel and the fire sensors, and between the control panel and any such control centre, can be effected via any suitable means, such as data lines, a data bus, a PSTN, intranet or internet or wirelessly. A dedicated, secure communications link is preferred.

[0031] As already indicated, processing means can be provided onboard the fire sensors. However, in a preferred fire detection system, the control panel comprises a processor adapted to, for the or each fire sensor: determine whether the external detection signal meets a predetermined trigger criterion and, if so, to generate the trigger signal; and/or evaluate whether the internal detection signal meets a predetermined alarm criterion, if so, to generate an alarm signal and, preferably, if not, to generate a deactivate signal whereby the controller deactivates the fluid transport device. By carrying out this processing at the control panel, the onboard processing requirements of each individual fire sensor is significantly reduced. If the control panel is confirmed to generate the trigger signal, this is output to the sensor in order to activate the fan.

[0032] Similarly, where the fire detection system incorporates a fire sensor including an airflow sensor (as described above), the control panel preferably further comprises a processor adapted to: output a test signal to the controller at intervals to thereby intermittently activate the fluid transport device, to determine whether the corresponding airflow signal meets predetermined obstruction conditions; and if so to output an obstruction signal; and preferably, upon receipt of an obstruction signal, determine whether the external detection signal meets a predetermined open chamber alarm criterion different from the predetermined trigger criterion, and if so, to generate an alarm signal.

[0033] The alarm signals generated by the processor of the control panel (which is also known as a CIE - "Control and Indicating Equipment") can be output in any desirable way, for example to a control centre and/or to an alarm device such as a sounder or visible alarm means which may be included in the control panel or provided elsewhere within the fire detection system. Typical control panels indicate an alarm using a low power buzzer, LEDs and/or a display. Alarm devices such as sounders and strobes are usually sited around the monitored region(s), in communication with the control panel, and are more powerful.

[0034] Preferably, the or each fire sensor is loop powered from the control panel. That is, each fire sensor draws a power supply from the control panel (which itself may be powered by the mains, for example). The power supply may conveniently utilise the same lines as the data communication. The fire sensors may alternatively or additionally be provided with individual power supplies such as batteries, which may act as a backup supply if required.

[0035] The invention further provides a method of detecting fire in a monitored region using a fire sensor or a fire detection system as described above. The method comprises: monitoring for the presence of fire products in the monitored region using an external detector assembly adapted to output a corresponding external detection signal; determining whether the external detection signal meets a predetermined trigger criterion and, if so, generating a trigger signal; upon occurrence of a trigger signal, activating a fluid transport device to thereby draw a sample of the atmosphere from the monitored region into a chamber for analysis by an internal detector assembly adapted to detect fire products within the chamber and to output a corresponding internal detection signal; evaluating whether the internal detection signal meets a predetermined alarm criterion, if so, to generate an alarm signal. As described above, the use of an external detector assembly to generate a trigger signal upon the occurrence of apparent fire conditions, which causes active sampling of the atmosphere in the monitored region into an internal chamber, and the provision of an internal detector to carry out a final analysis, solves numerous problems.

[0036] As already described, after activation, the fan or other fluid transport device could continue to run for a set period of time. However, in a preferred method, in the evaluating step, if the internal detection signal does not meet the predetermined alarm criterion, a deactivation signal is generated whereby the fluid transport device is deactivated. Preferably, when the fluid transport device is activated, or after an alarm signal, it operates intermittently according to a predetermined duty cycle. A low duty cycle of less than 50%, better still around 25%, is preferred.

[0037] Where the external detector assembly is arranged to receive a background level detection signal in the absence of fire products, the method preferably further comprises generating a fault signal if the external detection signal falls below the background level. The fault signal can be used to activate a fault indicator or to request servicing of the fire sensor.

[0038] Where the fire sensor comprises an airflow sensor, the method preferably further comprises intermittently activating at intervals the fluid transport device, determining whether the corresponding airflow signal meets predetermined obstruction conditions, and if so outputting an obstruction signal. The obstruction signal can be used to trigger a fault indicator or to request servicing of the fire sensor. Preferably, the method includes a fallback mode whereby upon receipt of an obstruction signal, it

is determined whether the external detection signal meets a predetermined open chamber alarm criterion different from the predetermined trigger criterion, and if so, an alarm signal is generated. This enables the fire sensor to provide some level of protection whilst awaiting repair. The predetermined open chamber alarm criterion is preferably less sensitive to potential fire products than the predetermined trigger criterion, in order to reduce the occurrences of false alarms in this fallback mode.

[0039] Examples of fire sensors, fire detection systems and methods of detecting fire in accordance with the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates schematically a first embodiment of a fire sensor;

Figure 2 shows components of a second embodiment of a fire sensor,
disassembled for clarity;

Figure 3 shows the fire sensor of Figure 2, fitted into a surface;

Figure 4 shows selected components of the fire sensor of Figure 2 in greater detail;

Figure 5 is a schematic diagram of a first embodiment of a fire detection system;

Figure 6 is a flow diagram illustrating the steps involved in a first embodiment of a method for detecting fire;

Figure 7 is a flow diagram showing further steps that may be involved in the method of detecting fire;

Figure 8 is a flow diagram showing steps involved in detecting a fault on the fire sensor;

Figure 9 is a flow diagram showing steps involved in detecting an obstruction of the fire sensor; and

Figure 10 is a flow diagram showing steps involved in operating in a fallback mode for detecting a fire.

[0040] As already indicated, the presently disclosed technique is particularly advantageously implemented in the form of a low-profile point fire sensor and as such, the ensuing description will focus on this example. However, it will be appreciated that the apparatus and methods to be described could equally well be implemented in conventionally mounted fire sensors.

[0041] Figure 1 shows a first embodiment of a fire sensor in terms of its main functional components. The sensor 1 is disposed within or adjacent to a monitored region M, for example a room (or a portion of a room) within a building. The fire sensor 1 is typically mounted to a surface of the monitored region M, preferably a ceiling or some or other horizontal surface close to the upper reaches of the monitored region, since fire products such as smoke typically rise. Fire sensor 1 includes an internal chamber 2 which is arranged to be in communication with the atmosphere within the monitored region via at least an inlet 2a and, preferably, an outlet 2b. In alternative implementations, the inlet and outlet could be combined in the form of a single port, or the outlet could be arranged to vent into some space other than the monitored region (for example, outside the building). A device 3 for transporting air from the monitored region into the chamber 2 is provided. In the example of Figure 1, this is disposed in the inlet channel 2a although many other configurations are possible. For example, the device 3 could be located within the chamber 2 or in the outlet 2b. Typically, the device 3 comprises a fan arranged to draw air and fire products, if present, from the monitored region M into the chamber 2. However, a pump or vacuum could be used analogously. The solid arrows in Figure 1 indicate the general movement of air into and out of the chamber 2 when the fan 3 is active.

[0042] An external detection assembly 4 is provided which is arranged to sense the presence of fire products within the monitored region M (but outside the chamber 2). This is represented by the chain-dashed lines suggesting a field of view of the detector assembly (though the detectors need not be optical). The external detection assembly 4 can be arranged to detect any desirable fire product and the type of sensor components selected will depend on the environment in which the sensor is to operate. Fire products include any detectable fire phenomena. Typical examples include smoke and other aerosols, combustion gases such as carbon monoxide, carbon dioxide, hydrogen and NO_x, heat from the fire, infrared radiation and the presence of flames. The external detector assembly could monitor the region for any one or a combination of such fire products. In preferred implementations, as will be described further below, the external detector assembly 4 includes at least one open chamber optical scatter sensor which will be responsive to the approach of smoke or aerosols generated by the fire. Alternatively or in addition, the external detector assembly 4 could include one or more gas sensors (electrochemical, optical or otherwise), a heat detector such as a thermistor (preferably a negative temperature coefficient thermistor), or an infrared detector such as a pyroelectric sensor which is capable of detecting wavelengths known to correspond to fires (for example, a hot flame can emit radiation of less than 1000 nm in wavelength), or a flame detector, typical examples of which provide a detector capable of receiving radiation in a suitable waveband (e.g. approximately 4.3μm wavelength to correspond to a typical hydrocarbon fire) together with a processor for identifying flicker in the detected signal indicative of flames. Any combination of such sensors could be provided to make up the external detector assembly 4.

[0043] The internal detection chamber 2 is provided with an internal detector assembly 5 for sensing fire products within the chamber 2. Again, the internal detector assembly 5 can include any desirable sensor types such as optical scatter sensors and/or a obscuration sensor, dual angle optical scatter sensors (to be described further below), gas sensors or conventional ionisation smoke sensors, or any combination thereof. An obscuration sensor typically comprises a radiation emitter aligned with a

radiation detector such that, in the absence of fire products, the detector receives radiation. As smoke or other aerosols build up in the chamber between the emitter and detector, the amount of received light drops. The obscuration sensor is quite sensitive to black smoke (since it absorbs light). However, when the path between the emitter and detector is short (as may be the case in a point-type sensor) then the drop in received light will also be small - possibly less than a 0.1 % drop in the signal level.

[0044] In operation, the fan 3 (and preferably the internal detector assembly 5) is inactive by default, except for periodic monitoring as will be discussed below. The external detector assembly 4 is used to continually monitor for fire products within the monitored region. The internal detector assembly 5 outputs a signal (termed the internal detection signal) which is processed and compared with predetermined trigger criteria to determine whether the signal is indicative of fire conditions. The nature of the predetermined trigger criterion will depend on the type of sensors deployed and the sensitivity required. For example, where the external detector assembly 4 comprises one or more optical scatter sensors, the external detection signal will correspond to the amount of radiation received at one or more detectors. The predetermined trigger criterion may be where the detected radiation intensity increases past a certain threshold, or by a certain proportion. Where multiple sensor types are provided, the output from each may be evaluated in combination with one another to judge the likelihood of fire. If the predetermined trigger criterion is met, a trigger signal is generated. This processing may be carried out either onboard the sensor unit 1, or remotely. In the present case, a controller 6 is included in the sensor 1, which also has processing capabilities. Here, the controller 6 is also in communication with a remote system (which will be described further below) via data connectors 7, although this need not be the case if the sensor is designed to be a standalone unit. The occurrence of a trigger signal causes the controller 6 to activate the fan 3, thereby drawing a sample of the atmosphere within the monitored region M into the chamber 2. If the internal detector assembly 5 is not already active, the trigger signal is also used to activate the internal sensors.

[0045] Air and fire products, if present, are thus drawn into the detection chamber 2 where the levels of any fire products build up quickly due to the fan 3. The internal detector assembly 5 outputs the signal, referred to as the internal detection signal which is used to determine whether fire conditions exist by comparison with predetermined alarm criterion which, again, will depend on the nature of the sensors included in the internal detector assembly. For example, where the internal detector assembly 5 includes an optical scatter sensor, the criterion may correspond to a threshold level in the detected signal. Likewise, where a gas sensor is provided, if the output signal exceeds a certain limit the criterion may be met. If multiple sensors are provided, a combination of criteria may be specified. If the alarm criterion is met, an alarm signal is generated. Again, this processing can be carried out onboard the sensor unit, by processor/controller 6, or remotely. The alarm signal can be used to actuate an audible and/or visible alarm and may additionally or alternatively be communicated to a control centre or premises owner as desired.

[0046] If the internal detection signal does not meet the predetermined alarm criterion, i.e. the trigger signal was a false alarm, the controller preferably deactivates the fan. Alternatively, the fan can automatically deactivate after a set time period. The provision of an internal detection chamber with an event-triggered fan greatly reduces the occurrence of false alarms as compared with conventional open chamber designs. Since the fan is only intermittently operated, power consumption is minimal and the fan's lifetime is greatly increased.

[0047] Figure 2 shows a second embodiment of the fire sensor in exploded view for clarity. The sensor comprises three main units: a flat ceiling plate 21 which sits substantially flush with a ceiling or other surface of the monitored region in use, a housing 25 which accommodates the functional components of the sensor and which is recessed into the ceiling in use, and an assembly 27 made up of a support plate 28 on which the functional components are mounted. The assembly 27 is located within the housing 25 in use. In Figure 2, the solid arrows represent the air path through the sensor, those in dashed lines being internal to the sensor and those in solid lines representing movement in the monitored region.

[0048] In this example, the external detector assembly 14 comprises two optical scatter sensors. The components making up the optical scatter sensors are all labelled 14 for clarity. The operation of the optical scatter sensors will be described further below in relation to Figure 3. When the signal from the optical scanner sensors 14 meets the predetermined trigger criterion, a fan 13 is activated. In this example, the fan 13 is a centrifugal fan, having a central inlet 13a covered by a mesh or filter 23a and a peripheral output 13b which directs airflow into the internal detection chamber 12. The output 13b may also be provided with a mesh or filter 23b. The meshes 23a and 23b protect the internal chamber from ingress of foreign bodies such as insects or spiders. A standard, relatively coarse mesh or filter can be provided in most scenarios, or a high-filtration version may be provided if the environment is particularly dusty, for example. The internal detection chamber 12 and internal detection assembly 15 will be described in more detail below in relation to Figure 4. The chamber 12 is completed by housing 25 when the sensor is fully assembled.

[0049] On actuation of the fan, air is drawn into the sensor through a substantially annular inlet provided in ceiling plate 21 between central disk portion 21 a and peripheral disk portion 21 b, joined by bridges 22. The inlet could if desired be covered by a further mesh or filter to assist in ingress protection. The airflow passes through

aperture 26a provided in the housing 25 which is co-located with central inlet point 13a of the fan 13. After passing through the chamber 12, the flow of air exits through aperture 26b provided in housing 25 which transfers the airflow to a central outlet point 12b through the ceiling plate 21, returning to the monitored region.

[0050] Figure 3 shows the assembled sensor unit in-situ and it will be noted that only plate 21 is visible since the remainder of the sensor unit is recessed into the ceiling C. In this example, the sensor rotates then locks in to a base (not shown) which makes electrical connection to plate 28. This is typically achieved using a removal tool to grip and turn the sensor. An additional tool can be used to lock the sensor in place, so that it cannot be removed by hand. In an alternative ceiling plate 21 could be provided with grips, e.g. larger air entry apertures, to allow for rotation by hand. An annular mounting ring 29 is affixed to the ceiling C for engagement with the ceiling plate 21. It will be noted that ceiling plate 21 sits substantially flush with the ceiling, providing no ligature points and a clean aesthetic.

[0051] The solid arrows show the airflow path when the fan 13 is active. Air and fire products, if present, are drawn through the annular inlet 12a into the sensor and output, after analysis, through central output point 12b. The result is a substantially toroidal (doughnut-shaped) circulation path below the sensor. Similar airflows could be achieved by providing multiple inlet apertures spaced around the outlet. Alternatively, a central inlet could be surrounded by one or more outlets (which may form an annulus), although this is less preferred since this could obstruct smoke approaching the sensor horizontally from reaching the inlet, thus delaying detection times. The circulation of the atmosphere within the monitored region adjacent to the sensor causes mixing and ensures that any fire products present, indicated by regions FP in Figure 3, will be sampled by the sensor even if stratification has occurred. The toroidal circulation path illustrated is considered provide particularly efficient mixing. However, other circulation routes may also be effected. For example, the single inlet and single outlet arranged as shown in Figure 1 may be found to provide adequate mixing in certain environments.

[0052] Figure 3 also shows components of the external detector assembly 14 in more detail. In this embodiment, the external detector assembly 14 comprises two optical scatter sensors arranged to operate at different angles. The principles of operation of optical scatter sensors is described in more detail in US-A-6,515,589. Essentially, each optical scatter sensor includes a radiation emitter such as an LED, arranged to produce a beam of radiation (preferably collimated) at a certain angle from the ceiling plate, plus a detector element which is arranged off-beam such that, under normal conditions, little or no radiation would be received. Any desirable wavelength of radiation could be utilised, however infrared wavelengths are preferred. Interception of the radiation beam by fire products such as smoke and other aerosols cause scattering of the radiation, substantially increasing the amount detected by the photodetector. The smaller the angle of the radiation beam, the closer the fire products must be to the sensor for scattering to occur.

[0053] Conveniently, the radiation detector of each optical scatter sensor forms part of a transimpedence amplifier and its output is sampled by an ADC port of a microcontroller. The microcontroller has a software gain factor that can be used to calibrate the sensor. For example, during manufacture, the sensor (or an identical sample) may be placed in a smoke tunnel in order to calibrate the sensitivity of each optical sensor to around 250 bits per dB/m (1 dB is about a 20% obscuration per metre). Trigger / alarm levels are normally set at a small fraction of a dB/m. A decibel is a logarithmic measurement of power, so decibels per metre (dB/m) is the power loss over a metre. In the present case this is calibrated using grey wood smoke. However all scatter angle sensors need not be calibrated the same and different aerosols produce different sensitivities.

[0054] In the present embodiment, two such optical scatter sensors are provided, 14a and 14b, each having a radiation emitter 14a', 14b' such as an LED and a corresponding radiation detector 14a", 14b" such as a photodiode. In this example, the emitters and detectors are arranged in pairs, one from each sensor, on either side of the outlet 12b. Other arrangements are possible but this is particularly preferred for reasons that will be described below.

[0055] The first optical scatter sensor 14a has a beam angle α greater than the beam angle β of the second optical scatter sensor. As shown in Figure 3, this means that the first optical scatter sensor 14a will be triggered by fire products FP located further from the sensor than will be the second optical scatter sensor 14b. The distance over which fire products can be detected is thereby extended by the use of the two different scatter angles. In addition, it becomes possible to track the transport of the fire products (such as smoke) towards the sensor, since the first scatter sensor 14a will trigger before the second 14a. Of course, any number of such scatter sensors with different angles could be provided to further increase the range of this tracking. In preferred embodiments, the emitters and detectors are not tightly collimated so that a range of distances is monitored by each scatter sensor pair. Each scatter sensor comprises a photodetector producing a 8 bit (256 ADC levels) output. As the smoke rises and intersects a greater proportion of the scatter sensor's radiation beam, the level of the output will rise, making it possible to track the movement of the smoke across the beam (and towards the sensor). It is particularly advantageous if the two monitored ranges are arranged to overlap, so that an unbroken monitored area under the sensor is obtained.

[0056] This can also be used to provide the sensor with multiple levels of sensitivity which can be selected from as appropriate for the environment under test. For example, where very high sensitivity is required, the predeter-

mined trigger criterion could be configured such that tripping of the first scatter angle 14a (i.e. the detector 14a" outputting a signal greater than a certain threshold) will cause a trigger signal to be generated and the fan activated. Alternatively, if less sensitivity is required, tripping of the second angle 14b may be used as the trigger criterion. The sensitivity (or trip levels) of both scatter sensors could be adjusted independently, as well as OR logic or AND logic being applied to the operation of the fan (i.e. in the trigger criterion). This, in combination with selection of the appropriate sensitivity for the internal detection chamber, makes this sensor particularly suitable for a diverse range of applications.

[0057] Figure 4 shows the internal components of the sensor in more detail. Again, the external detector assembly components 14 are visible and it will be noted that alongside is provided a indicator light 24, preferably a bi- or tri- colour LED for indicating status of the sensor unit.

[0058] The fan 13 is preferably a centrifugal fan capable of generating a high static pressure although many other fan types could be utilised. A high static pressure ensures the airflow is driven through the chamber 2 effectively. The centrifugal fan is preferably arranged in the manner described in our co-pending European patent application entitled "Fire Sensor and Method for Detecting Fire" (Publication number EP 2320398), filed on even date herewith, which reduces the sensitivity of the internal optical detector to steam, thereby further reducing the possibility of false alarms.

[0059] The detection chamber 12 is shaped to accommodate the components making up the internal detector assembly 15. In this example, these include a gas sensor 15a which is accommodated in a curved annex of the chamber 12, as well as a dual angle optical scatter sensor, having components 15b, 15c and 15d. The gas sensor 15a is preferably a carbon monoxide detector although many other gases could be sensed as appropriate to the environment being monitored. Electrochemical, optical or other gas sensor types may be implemented as appropriate. Suitable gas sensors can be obtained, for example, from City Technology Limited of Portsmouth, UK. The principle of operation of a dual-angle optical scatter sensor is described in US-A-6,218,950. In the present example, a radiation emitter 15b is provided with two radiation detectors 15c and 15d, the first arranged to receive radiation at a forward scattering angle (15c), and the second at a back scattering position (15d). A beam of light is emitted by element 15b, which may be an LED or similar, preferably emitting in the infrared range, and, when smoke or aerosols are present in the chamber 12, the beam is scattered. The amount of forward scattering and back scattering depends on the nature of the fire product within the chamber, and the ratio of the forward and back scatter signals can be used to judge whether alarm conditions are met. As described in US-A-6,218,950, the use of the ratio is particularly advantageous since the occurrence of false alarms is further reduced. It should be noted that the dual angle optical scatter sensor could alternatively comprise a single radiation detector and two radiation emitters arranged to emit beams of radiation making two different angles with the detector, which is advantageous in terms of cost. In this case, one of the emitters is pulsed on, and a reading obtained from the detector for the first scatter angle (in the form of a ADC output), then the other emitter is pulsed on and a reading obtained for the second scatter angle. The two readings can be processed (e.g. ratioed) in the same way as before to deduce whether fire conditions are met. The control of the optical elements 15a, 15b and 15c can be controlled by a processor onboard the sensor or remotely.

[0060] Like the external optical scatter sensors, the internal optical scatter sensor(s) may also be arranged such that the one or more photodiodes form part of transimpedence amplifiers, and are calibrated in the same way to appropriate levels of sensitivity.

[0061] The use of a fan for active sampling of the monitored region in the manner described above ensures that fire products around and below the sensor are drawn into the internal detection chamber. If a real fire is present, the sensed levels in the detection chamber quickly build up and a fire is quickly and accurately detected. On receipt of the trigger signal, the fan can be continuously powered for a period of time whilst the internal analysis is carried out. If power consumption needs to be reduced during this period (e.g. due to triggering of several sensors in a system), the fan can be pulse operated during this time. Further, once the presence of fire has been confirmed, the fan is preferably intermittently operated at a low duty cycle of around 25% (e.g. 10 seconds on, 30 seconds off) so that the build up of the fire in the monitored region can be monitored by the internal detection chamber.

[0062] When triggered, the fan speed can be reasonably low since the proximity of the chamber to the monitored region M means that there is practically no transport time required for conveying the sample down long air inlets (as would be the case in a conventional ASD) which means that the average power required for the fan is minimal. As such, the device is suitable for battery operation, as well as loop-powered operation in a fire detector system as will be described below.

[0063] Since the airflow through the chamber is event triggered, the possibility of the chamber or mesh 23a/23b being blocked by debris is effectively no more significant than a sensor without a fan. In general, a standard smoke detector mesh of reasonably coarse construction can be used in this design, although a high filtration filter could be provided for use in more difficult conditions. Again, since the fan is only triggered sporadically, the lifetime of such a high filtration filter is massively extended.

[0064] As already alluded to above, one further advantage of the disclosed sensor configuration occurs in situations where a thermal barrier arises at the ceiling level. This can take place where smoke and hot gases rise from

the fire and become diluted with clean, cool air which is drawn into the plume. If the ceiling is high and the ambient temperature of the uppermost area within a protected space is high, the plume of smoke and hot gases may reach ambient temperature before reaching the ceiling. The plume will then spread out to form a smoke layer under the thermal barrier before it reaches the ceiling. This is known as stratification, and above the layer, the smoke and even the gases will not easily reach concentrations sufficient to be detected by conventional ceiling mounted detectors, until ultimately the fire grows and releases enough heat to overcome the thermal barrier. If known, high profile detectors are mounted below the ceiling, at an expected stratification level, and it does not occur, detection might be dangerously delayed, as a narrow plume could miss the detector, while at the ceiling level, hot gases and smoke will float horizontally across it (missing the detection chamber). In contrast, the provision of the external detector assembly described above enables a relatively large area to be monitored below the sensor. By arranging for the fan to be triggered by the detection of relatively small levels of smoke or small changes in the levels of gas, such as CO, the sensor is particularly effective in allowing early fire detection in such situations, whilst not suffering unduly from an increased number of false alarms, as a result of the use of the internal detection chamber.

[0065] The fire sensor also includes a number of optional features for self diagnosis of faults or tampering events. Referring back to Figure 3, as previously mentioned, the two open chamber optical scatter sensors 14a and 14b, are preferably arranged with the detector of one adjacent to the emitter of the other and vice versa. In a preferred embodiment, the emitter and detector adjacent to one another are positioned in such a way that radiation bleed occurs between the transmitter element of one sensor and the receiving photodiode of the other. In other words, a small amount of radiation is continuously received by each of the detectors. The corresponding 'background' signal level acts as a minimum threshold for normal operation. Should one of the components fail, the detected signal will fall to zero, upon which a fault signal can be generated. The same mechanism will also identify covering or painting over of the sensor, both of which would obstruct the background reading.

[0066] As well as the sensors in the internal detection assembly being periodically monitored, the fan and airflow can also be periodically monitored by turning on the fan for a short period at regular intervals, on a very low duty cycle basis. To monitor the airflow, an airflow sensor may be provided, indicated by 16 in Figure 2. Many suitable airflow detectors are available and, in a preferred implementation, the airflow detector 16 comprises a pair of thermistors of which the first is self-heated by passing an electrical current therethrough and the other is unheated, remaining at ambient temperature. In the presence of a flow of air, the heated thermistor will lose heat, and the change in the temperature difference between the elements is indicative of the airspeed. The temperature of each element can be monitored by measuring the element's electrical resistance. Other types of airflow sensor such as a vane meter sensor or a membrane sensor could be used instead.

[0067] Thus, when the fan is switched on, the signal from the airflow sensor can be evaluated to determine whether it meets predetermined obstruction conditions i.e. the detected airspeed is less than a set level. If so, an obstruction signal can be output, and used to call for maintenance. The airflow sensor signal could also be sampled upon activation of the fan at a trigger event, to confirm that the sensor is operating correctly before making a decision as to whether to generate an alarm signal. If no obstruction is detected, the status of the sensor is known to be operational. This offers the possibility of extending the time period between on-site sensor tests, which would be a significant benefit to the premises owner. Otherwise, regular visits are necessary to ensure that the sensor has not been obstructed (e.g. covered by a plastic bag or painted over) since this will not be deducible from the internal detection signal alone.

[0068] Where an obstruction signal is generated, the sensor can optionally operate in a fallback mode where the external detection signal is used as the basis for issuing an alarm signal. In other words, in the fallback mode, the sensor operates as an open chamber sensor until it can be repaired. However, to avoid numerous false alarms, rather than using the predetermined trigger criterion to determine whether to issue an alarm, instead, the external detection signal is compared with a different predetermined alarm criterion which is less sensitive than the predetermined trigger criterion, such that greater evidence of fire will be required before an alarm is issued than would result in the generation of a trigger signal.

[0069] As indicated above, the fire sensor could be a standalone unit, including onboard processing means and, if desired, alarm outputting means or other status indicators to alert the user should a fire scenario occur or a fault be detected. For instance, indicator 24 could be used as a fault indicator and a sounder may be included in housing 25. However, in many situations, the fire sensor will form part of a fire detection system, of which an example is schematically depicted in Figure 5. In the fire detection system, one or more fire sensors of the sort shown in Figure 1 or Figure 2 are provided, each being arranged to detect fires within a corresponding monitored region M. Each of the sensors is arranged to communicate with a control panel 30 by any appropriate communication means, wired or wireless. Each of the sensor units preferably includes an encoded address such that the control panel can corroborate received signals with actual locations of the monitored regions. The amount of processing carried out at the control panel and locally at each sensor unit can be selected as desired. At the least, the control panel 30 typically includes a processor 31 capable of monitoring the status of each of the sensor elements 20, based on whether or not an alarm

signal has been output. However, in many cases, the processor 31 will also carry out one or more of the above described processing routines, and can be responsible for all of the processing if desired, in which case no processing component need be provided locally. The control panel 30 will typically also include a user interface 32 whereby commands may be input into the system, for example to retrieve the status of one or more of the sensors or to initiate a test, such as an airflow test, as described above. The control panel 30 may also include communications means 33 for communicating with a remote control centre used for example to alert the fire service to the occurrence of a fire signal on one or more of the sensors 20. The control panel 30 may include other components such as alarm units and/or a visual display panel as required.

[0070] As described above, the non-continuous use of the fan in each sensor unit and the low fan speed required (around 4000 rpm) means that the average power required for each sensor unit is relatively low. As such, the sensor unit can be loop-powered from the control panel 30 which can accommodate a large number of this type of sensor on its loops. The occurrence of a fire signal will generally cause a sounder to start (either onboard the sensor or elsewhere) which uses up more significant current and, as such, the control panel 30 may include a limitation on the number of sensors in the system which can activate their fan simultaneously, once an alarm has been initiated. For example, a typical system can handle 32 fires before running out of bandwidth.

[0071] Methods of detecting fire using the above described apparatus will now be described with reference to flow charts of Figures 6 to 10.

[0072] Figure 6 shows primary steps involved in the detection of a fire according to an embodiment. From starting point A, in step S100, the external detection signal E output by the external detector assembly is monitored. In step S102, it is determined whether the external detection signal E meets the predetermined trigger criterion. As indicated above, this criterion will depend on the nature of the external detector assembly and the sensitivity required in the circumstances. For example, a typical smoke obscuration level at which a trigger signal will be generated may be around 0.1dB/m (= 2% obscuration per metre). If the trigger criterion is not met, the flow returns to point A and monitoring of the external detection signal E is continued.

[0073] If the external detection signal E does meet the predetermined trigger criterion, in step S104, the fan or other fluid transport device is activated to draw air from the monitored region into the internal detection chamber. If the internal detector assembly requires activating, this is also initiated. In step S106, the internal detection signal I is monitored and in step S108 it is determined whether the internal detection signal I meets a predetermined alarm criterion. Again, this criterion will depend on the nature of the internal detectors. A typical smoke obscuration level at which an alarm signal will be generated may be around 0.2dB/m (= 4% obscuration per metre). If the criterion is not met, it is concluded that fire conditions are not present and the fan can be deactivated in step S109. The system then returns to start point A.

[0074] If the internal detection signal I does meet the predetermined alarm criterion, in step S110, an alarm signal is output. The output signal can be used to trigger an alarm unit such as a sounder or a visual device and/or to notify a remote control centre.

[0075] After generation of an alarm, the fan could be deactivated or could continue to run for some set period of time. However, preferably, the method moves to routine B, depicted in Figure 7. In step S112, the fan is operated intermittently at a low duty cycle of around 25% (e.g. 10 seconds on, 30 seconds off). The internal detector signal I is monitored in step S114, and in step S116, it is determined whether the internal detection signal I meets the predetermined alarm criterion. If so, this means that fire conditions are still evident and the system returns to point B to continue intermittent monitoring. This enables the system to monitor the building up of fire around the sensor and to identify the increase of fire intensity to "superfire" level if desired (upon the internal detection signal meeting a 'superfire' criterion). If the internal detection signal I no longer meets the alarm criterion, the fan can be deactivated. This minimises the amount of power used by the system. Optionally, prior to deactivating the fan, in step S117, the chamber is purged by continuing operation of the fan for a period of time. This ensures that the chamber is left containing clean air after a fire. The fan is then ultimately deactivated in S118. The system then returns to its default position A until the monitored external levels once again indicate a possible fire.

[0076] Figure 8 depicts routine C for detecting faults affecting the external detector assembly. This optional routine runs in parallel to the main detection technique already described. In the step S202, the external detection signal E is monitored. In step S204, it is determined whether the external detection signal is at least as great as the background level expected by the radiation bleed between the two optical scatter sensors as described in relation to Figure 3 above. If so, this indicates that the external detection assembly is operating correctly and the system returns to point C to continue this monitoring. If the external detection signal E falls below the expected level, in step S206, a fault signal is output, indicative of a non-operational component or tampering with the sensor. The fault signal can be used to illuminate a status indicator such as 24 shown in Figure 2 and/or to communicate with a remote device such as control panel 30 to request attention. The system returns to point C in order that the fault signal will be repealed once the background level is re-established.

[0077] Figure 9 shows routine D for detecting airway obstructions where an airflow sensor has been provided. In step S302, the fan is operated. This may be instigated by routine A or B, already described, in the course of a

potential alarm scenario. However, preferably, irrespective of the occurrence of any trigger signal, the fan is intermittently tested at regular intervals. In step S304, the airflow signal A from the airflow sensor is monitored and in step S306, it is determined whether the airflow signal A meets an obstruction criterion. If not, it is deemed that no obstruction exists and the system returns to point D. If the airflow signal does meet an obstruction criterion, an obstruction signal is output in step S308. The obstruction signal can be used to request maintenance or otherwise. However, preferably, the system switches into a fallback mode of operation as depicted in routine E of Figure 10. In step S402, the external detection signal E is monitored. In step S404, it is determined whether E meets a predetermined external detector alarm criterion. This alarm criterion is preferably not the same as the predetermined trigger criterion, in order to avoid frequent false alarms. Instead, the alarm criterion is less sensitive, requiring greater detection levels in order to meet the criterion. If the alarm criterion is not met, the routine returns to point E and continues to monitor the external detection signal. If the external detection signal E does meet the alarm criterion, an alarm signal is output and this can be used in the same way as that output in step S110 in routine A.

[0078] As noted above, fire alarm systems typically include alarm devices such as a sounder or strobe (flashing light) unit in communication with the sensor and/or control panel for alerting the occupants of the monitored region to a detected fire. In addition or as an alternative to such devices, the presently disclosed sensor unit may itself include an integral sounder and/or strobe which can be activated upon generation of an alarm signal. In one implementation, the sounder could take the form of a piezoelectric sounder.

[0079] The above described fire sensor could alternatively be combined into an addressable loudspeaker provided on the power/data loop of the fire alarm system. A loudspeaker produces a much higher quality audio output than is possible using a piezoelectric sounder. If it is desired to output a voice message using a piezoelectric sounder, it is necessary to use a pre-recorded phrase and to repeat playback of the phrase multiple times in order for its audience to assimilate and understand what is being said.

[0080] In contrast, the quality of a loudspeaker is such that a voice message can be readily understood and need only be issued once (or with a small number of repeats to ensure it is not missed). This allows for the use of live (rather than pre-recorded) voice messages.

[0081] Since the fire sensor can be designed to provide an essentially flat outer profile, it can be combined into a loudspeaker. For example, the external sensing components and air inlet can be arranged about the perimeter of the loudspeaker's sounding cone, with the internal detection chamber located behind the speaker. A similar configuration could also be implemented with a conventional open chamber low profile fire sensor (i.e. without an internal chamber), but the presently disclosed benefits and in particular the reduction in false alarms would be lost.

[0082] In an alternative implementation, rather than use a conventional loudspeaker assembly, a flat speaker technology could be used, incorporating the flat speaker into the ceiling plate of the low profile sensor.

Claims

1. A fire sensor (1) for detecting fire in a monitored region (M), the fire sensor (1) comprising:

   a chamber (2) in fluid communication with the monitored region M via at least one inlet (2a);
   an internal detector assembly (5) adapted to detect fire products within the chamber and to output a corresponding internal detection signal;
   an external detector assembly (4) adapted to detect fire products outside the chamber (2) in the monitored region and to output a corresponding external detection signal;
   a fluid transport device (3) adapted to draw a sample of the atmosphere from the monitored region into the chamber through the at least one inlet; and
   a controller (6) adapted to activate the fluid transport device (3) upon receipt of a trigger signal based on the external detection signal to thereby draw a sample of the atmosphere from the monitored region into the chamber for analysis by the internal detector assembly.

2. A fire sensor (1) according to claim 1, further comprising a processor adapted to determine whether the external detection signal meets a predetermined trigger criterion and, if so, to generate the trigger signal.

3. A fire sensor (1) according to claim 1 or claim 2, further comprising a processor adapted to evaluate whether the internal detection signal meets a predetermined alarm criterion, if so, to generate an alarm signal and, preferably, if not, to generate a deactivate signal whereby the controller (6) deactivates the fluid transport device.

4. A fire sensor (1) according to any of the preceding claims, wherein the internal detector assembly (5) comprises any of:

   an optical scatter sensor, comprising a radiation emitter and a radiation detector comprising a radiation emitter arranged to emit a beam of radiation, and a radiation detector disposed off the beam path, the receipt of radiation at the detector being indicative of optical scatter caused by

fire products intercepting the radiation beam;
a dual angle optical scatter sensor comprising either a radiation emitter and at least two radiation detectors arranged to receive radiation scattered at different angles from one another or a radiation detector and at least two radiation emitters arranged to emit beams at different angles to the detector;
an optical obscuration sensor;
a heat sensor;
a gas sensor adapted to detect one or more gaseous fire products, preferably carbon monoxide, carbon dioxide, hydrogen or NO_x; and/or
an ionisation smoke sensor.

5. A fire sensor (1) according to any of the preceding claims, wherein the external detector assembly (4) comprises any of:

at least one optical scatter sensor, comprising a radiation emitter arranged to emit a beam of radiation at a predetermined angle from the fire sensor, and a radiation detector disposed off the beam path, the receipt of radiation at the detector being indicative of optical scatter caused by fire products intercepting the radiation beam;
a gas sensor adapted to detect one or more gaseous fire products, preferably carbon monoxide, carbon dioxide, hydrogen or NO_x;
a flame detector, comprising a radiation detector adapted to receive thermal radiation from within the monitored region at a predetermined wavelength range, and a processor adapted to detect flicker in the received radiation indicative of a flame;
a heat sensor; and/or
an infrared radiation detector.

6. A fire sensor (1) according to claim 5, wherein the external detector assembly comprises first and second optical scatter sensors each as defined in claim 5, the first optical scatter sensor being arranged to emit a radiation beam at a first predetermined angle and the second optical scatter sensor being arranged to emit a radiation beam at a second predetermined angle which is less than the first such that the first optical scatter sensor is responsive to smoke products spaced further from the fire sensor compared to the second optical scatter sensor.

7. A fire sensor (1) according to claim 6, wherein the radiation emitter of the first or second optical scatter sensor is arranged to partially illuminate the radiation detector of the other optical scatter sensor such that a background level of radiation is detected in the absence of fire products.

8. A fire sensor (1) according to any of the preceding claims wherein the controller (6) is further adapted to intermittently activate the fluid transport device (3) after receipt of a trigger signal or an alarm signal according to a predetermined duty cycle, preferably a low duty cycle of less than 50%, still preferably around 25%.

9. A fire sensor (1) according to any of the preceding claims wherein the chamber (2) is provided with an outlet (2b) enabling the atmospheric sample to escape from the chamber to the monitored region M, the outlet (2b) being disposed adjacent to the inlet (2a) such that circulation of the atmosphere adjacent the fire sensor (1) within the monitored region is established when the fluid transport device (3) is active, preferably wherein the inlet (2a) comprises multiple inlet points surrounding the outlet (2b), or the outlet comprises multiple outlet points surrounding the inlet (2a), such that a substantially toroidal circulation path is established adjacent the fire sensor, the multiple inlet or outlet points preferably being arranged to form an annulus.

10. A fire sensor (1) according to any of the preceding claims further comprising an airflow sensor (16) adapted to detect the movement of fluid within the chamber or between the chamber and the monitored region and to output a corresponding airflow signal.

11. A fire sensor (1) according to claim 10 further comprising a processor adapted to output a test signal to the controller (6) at intervals to thereby intermittently activate the fluid transport device (3), to determine whether the corresponding airflow signal meets predetermined obstruction conditions, and if so to output an obstruction signal.

12. A fire sensor (1) according to claim 11 wherein the processor is further adapted to, upon receipt of an obstruction signal, determine whether the external detection signal meets a predetermined open chamber alarm criterion different from the predetermined trigger criterion, and if so, to generate an alarm signal.

13. A fire sensor (1) according to any of the preceding claims adapted to be mounted to a surface, preferably a ceiling, of the monitored region, the fire sensor further comprising a substantially flat plate (21, 28) adapted to engage and lie substantially flush with the surface in use, and being disposed between the monitored region M and the chamber (2).

14. A fire detection system, comprising at least one fire sensor (1, 20) in accordance with any of claims 1 to 13 and a control panel (30) arranged for communication with the or each fire sensor (20), the control panel (30) being adapted to monitor the status of the

or each fire sensor (20).

15. A fire detection system according to claim 14, wherein the control panel (30) comprises a processor (31) adapted to, for the or each fire sensor (20):

determine whether the external detection signal meets a predetermined trigger criterion and, if so, to generate the trigger signal; and/or
evaluate whether the internal detection signal meets a predetermined alarm criterion, if so, to generate an alarm signal and, preferably, if not, to generate a deactivate signal whereby the controller (30) deactivates the fluid transport device (3).

16. A fire detection system according to claim 14 or claim 15, when dependent on at least claim 10, wherein the control panel further comprises a processor (31) adapted to:

output a test signal to the controller at intervals to thereby intermittently activate the fluid transport device (3), to determine whether the corresponding airflow signal meets predetermined obstruction conditions, and if so to output an obstruction signal; and preferably
upon receipt of an obstruction signal, determine whether the external detection signal meets a predetermined open chamber alarm criterion different from the predetermined trigger criterion, and if so, to generate an alarm signal.

17. A method of detecting a fire in a monitored region using a fire sensor according to any of claims 1 to 13 or a fire detection system according to any of claims 14 to 16, comprising:

monitoring (S100) for the presence of fire products in the monitored region using an external detector assembly adapted to output a corresponding external detection signal;
determining (S102) whether the external detection signal meets a predetermined trigger criterion and, if so, generating a trigger signal:
upon occurrence of a trigger signal, activating (S104) a fluid transport device to thereby draw a sample of the atmosphere from the monitored region into a chamber for analysis (S106) by an internal detector assembly adapted to detect fire products within the chamber and to output a corresponding internal detection signal;
evaluating (S108) whether the internal detection signal meets a predetermined alarm criterion, if so, to generate an alarm signal.

18. A method of detecting a fire in a monitored region according to claim 17 wherein, in the evaluating step, if the internal detection signal does not meet the predetermined alarm criterion, to generate (S109) a deactivate signal whereby the fluid transport device is deactivated.

19. A method of detecting a fire in a monitored region according to any of claims 17 to 18 when dependent on claim 7 further comprising generating a fault signal if the external detection signal falls below the background level.

20. A method of detecting a fire in a monitored region according to any of claims 17 to 19 when dependent on claim 10, further comprising intermittently activating (S112) at intervals the fluid transport device, determining whether the corresponding airflow signal meets predetermined obstruction conditions, and if so outputting an obstruction signal; and preferably, upon receipt of an obstruction signal, determining whether the external detection signal meets a predetermined open chamber alarm criterion different from the predetermined trigger criterion, and if so, generating an alarm signal.

Patentansprüche

1. Feuersensor (1) zum Detektieren eines Feuers in einem überwachten Bereich (M), wobei der Feuersensor (1) Folgendes umfasst:

eine Kammer (2), die mit dem überwachten Bereich M über wenigstens einen Einlass (2a) in einer Fluidkommunikation steht;
eine interne Detektoranordnung (5), die dazu ausgelegt ist, Feuerprodukte in der Kammer zu detektieren und ein entsprechendes internes Detektionssignal auszugeben;
eine externe Detektoranordnung (4), die dazu ausgelegt ist, Feuerprodukte außerhalb der Kammer (2) in dem überwachten Bereich zu detektieren und ein entsprechendes externes Detektionssignal auszugeben;
eine Fluidtransportvorrichtung (3), die dazu ausgelegt ist, eine Probe der Atmosphäre aus dem überwachten Bereich durch den wenigstens einen Einlass in die Kammer zu saugen; und
eine Steuereinheit (6), die dazu ausgelegt ist, die Fluidtransportvorrichtung (3) bei Empfang eines Auslösersignals auf der Grundlage des externen Detektionssignals zu aktivieren, um **dadurch** eine Probe der Atmosphäre aus dem überwachten Bereich in die Kammer zur Analyse durch die interne Detektoranordnung zu saugen.

2. Feuersensor (1) nach Anspruch 1, der ferner einen Prozessor umfasst, der dazu ausgelegt ist, zu be-

stimmen, ob das externe Detektionssignal ein vorgegebenes Auslösekriterium erfüllt, und wenn ja, das Auslösesignal zu erzeugen.

3. Feuersensor (1) nach Anspruch 1 oder Anspruch 2, der ferner einen Prozessor umfasst, der dazu ausgelegt ist, zu bewerten, ob das interne Detektionssignal ein vorgegebenes Alarmkriterium erfüllt, und wenn ja, ein Alarmsignal zu erzeugen, und wenn nein, vorzugsweise ein Deaktivierungssignal zu erzeugen, wodurch die Steuereinheit (6) die Fluidtransportvorrichtung deaktiviert.

4. Feuersensor (1) nach einem der vorhergehenden Ansprüche, wobei die interne Detektoranordnung (5) eines der Folgenden umfasst:

einen optischen Streusensor, der einen Strahlungssender und einen Strahlungsdetektor, der einen Strahlungssender, der dazu ausgelegt ist, ein Strahlungsbündel zu emittieren, und einen außerhalb des Bündelwegs angeordneten Strahlungsdetektor enthält, umfasst, wobei der Empfang von Strahlung bei dem Detektor eine optische Streuung, die durch Feuerprodukte im Strahlungsbündel hervorgerufen wird, angibt;
einen optischen Doppelwinkel-Streusensor, der entweder einen Strahlungssender und wenigstens zwei Strahlungsdetektoren, die dazu ausgelegt sind, Strahlung, die unter verschiedenen Winkeln gestreut werden, zu empfangen, oder einen Strahlungsdetektor und wenigstens zwei Strahlungssender, die dazu ausgelegt sind, Bündel unter verschiedenen Winkeln zu dem Detektor auszusenden, umfasst;
einen optischen Verdunkelungssensor;
einen Wärmesensor;
einen Gassensor, der dazu ausgelegt ist, ein oder mehrere gasförmige Feuerprodukte, vorzugsweise Kohlenstoffmonoxid, Kohlenstoffdioxid, Wasserstoff oder NO_x, zu detektieren; und/oder
einen Ionisationsrauchsensor.

5. Feuersensor (1) nach einem der vorhergehenden Ansprüche, wobei die externe Detektoranordnung (4) eines der Folgenden umfasst:

wenigstens einen optischen Streusensor, der einen Strahlungssender, der dazu ausgelegt ist, ein Strahlungsbündel unter einem vorgegebenen Winkel von dem Feuersensor auszusenden, und einen Strahlungsdetektor, der außerhalb des Bündelwegs angeordnet ist, umfasst, wobei der Empfang der Strahlung bei dem Detektor eine optische Streuung angibt, die durch Feuerprodukte in dem Strahlungsbündel verursacht werden;
einen Gassensor, der dazu ausgelegt ist, ein oder mehrere gasförmige Feuerprodukte, vorzugsweise Kohlenstoffmonoxid, Kohlenstoffdioxid, Wasserstoff oder NO_x, zu detektieren;
einen Flammendetektor, der einen Strahlungsdetektor, der dazu ausgelegt ist, Wärmestrahlung von innerhalb des überwachten Bereichs in einem vorgegebenen Wellenlängenbereich zu empfangen, und einen Prozessor, der dazu ausgelegt ist, ein Flakkern in der empfangenen Strahlung, das eine Flamme angibt, zu detektieren, umfasst;
einen Wärmesensor; und/oder
einen Infrarotstrahlungsdetektor.

6. Feuersensor (1) nach Anspruch 5, wobei die externe Detektoranordnung einen ersten und einen zweiten optischen Streusensor umfasst, wovon jeder wie in Anspruch 5 definiert beschaffen ist, wobei der erste optische Streusensor dazu ausgelegt ist, ein Strahlungsbündel unter einem ersten vorgegebenen Winkel auszusenden, und der zweite optische Streusensor dazu ausgelegt ist, ein Strahlungsbündel unter einem zweiten vorgegebenen Winkel, der kleiner als der erste Winkel ist, auszusenden, so dass der erste optische Streusensor auf Rauchprodukte anspricht, die im Vergleich zu dem zweiten optischen Streusensor weiter von dem Feuersensor entfernt sind.

7. Feuersensor (1) nach Anspruch 6, wobei der Strahlungssender des ersten oder des zweiten optischen Streusensors dazu ausgelegt ist, den Strahlungsdetektor des anderen optischen Streusensors teilweise zu beleuchten, so dass ein Hintergrundpegel der Strahlung bei Abwesenheit von Feuerprodukten detektiert wird.

8. Feuersensor (1) nach einem der vorhergehenden Ansprüche, wobei die Steuereinheit (6) ferner dazu ausgelegt ist, die Fluidtransportvorrichtung (3) nach dem Empfang eines Auslösesignals oder eines Alarmsignals in Übereinstimmung mit einem vorgegebenen Tastgrad, vorzugsweise einem niedrigen Tastgrad von weniger als 50 %, stärker bevorzugt von etwa 25 %, intermittierend zu aktivieren.

9. Feuersensor (1) nach einem der vorhergehenden Ansprüche, wobei die Kammer (2) mit einem Auslass (2b) versehen ist, der einer atmosphärischen Probe ermöglicht, aus der Kammer in den überwachten Bereich M zu entweichen, wobei der Auslass (2b) in der Nähe des Einlasses (2a) angeordnet ist, so dass ein Zirkulation der Atmosphäre in der Nähe des Feuersensors (1) innerhalb des überwachten Bereichs geschaffen wird, wenn die Fluidtransportvorrichtung (3) aktiv ist, wobei vorzugsweise der Einlass (2a) mehrere Einlassstellen umfasst, die den Auslass (2b) umgeben, oder der Auslass mehrere Auslass-

stellen umfasst, die den Einlass (2a) umgeben, so dass ein im Wesentlichen toroidförmiger Zirkulationspfad in der Nähe des Feuersensors geschaffen wird, wobei die mehreren Einlass- oder Auslassstellen vorzugsweise so angeordnet sind, dass sie einen Ringraum bilden.

10. Feuersensor (1) nach einem der vorhergehenden Ansprüche, der ferner einen Luftströmungssensor (16) umfasst, der dazu ausgelegt ist, die Bewegung von Fluid in der Kammer oder wischen der Kammer und dem überwachten Bereich zu detektieren und ein entsprechendes Luftströmungssignal auszugeben.

11. Feuersensor (1) nach Anspruch 10, der ferner einen Prozessor umfasst, der dazu ausgelegt ist, ein Testsignal zu der Steuereinheit (6) in Intervallen auszugeben, um **dadurch** die Fluidtransportvorrichtung (3) intermittierend zu aktivieren, um zu bestimmen, ob das entsprechende Luftströmungssignal vorgegebene Verstopfungsbedingungen erfüllt, und wenn ja, ein Verstopfungssignal auszugeben.

12. Feuersensor (1) nach Anspruch 11, wobei der Prozessor ferner dazu ausgelegt ist, bei Empfang eines Verstopfungssignals zu bestimmen, ob das externe Detektionssignal ein vorgegebenes Alarmkriterium für eine offene Kammer, das von dem vorgegebenen Auslösekriterium verschieden ist, erfüllt, und wenn ja, ein Alarmsignal zu erzeugen.

13. Feuersensor (1) nach einem der vorhergehenden Ansprüche, der dazu ausgelegt ist, an einer Oberfläche, vorzugsweise einer Decke des überwachten Bereichs montiert zu werden, wobei der Feuersensor ferner eine im Wesentlichen ebene Platte (21, 28) aufweist, die dazu ausgelegt ist, im Gebrauch mit der Oberfläche in Eingriff zu sein und hierzu im Wesentlichen bündig zu liegen, und zwischen dem überwachten Bereich M und der Kammer (2) angeordnet ist.

14. Feuerdetektionssystem, das wenigstens einen Feuersensor (1, 20) nach einem der Ansprüche 1 bis 13 und eine Steuerkonsole (30), die für eine Kommunikation mit dem oder jedem Feuersensor (20) ausgelegt ist, umfasst, wobei die Steuerkonsole (30) dazu ausgelegt ist, den Status des oder jedes Feuersensors (20) zu überwachen.

15. Feuerdetektionssystem nach Anspruch 14, wobei die Steuerkonsole (30) einen Prozessor (31) umfasst, der für den oder jeden Feuersensor (20) dazu ausgelegt ist:

zu bestimmen, ob das externe Detektionssignal ein vorgegebenes Auslösekriterium erfüllt, und wenn ja, das Auslösesignal zu erzeugen; und/oder

zu bewerten, ob das interne Detektionssignal ein vorgegebenes Alarmkriterium erfüllt, und wenn ja, ein Alarmsignal zu erzeugen, und wenn nein, vorzugsweise ein Deaktivierungssignal zu erzeugen, wodurch die Steuereinheit (30) die Fliudtransportvorrichtung (3) deaktiviert.

16. Feuerdetektionssystem nach Anspruch 14 oder Anspruch 15, wenn abhängig wenigstens von Anspruch 10, wobei die Steuerkonsole ferner einen Prozessor (31) umfasst, der dazu ausgelegt ist:

ein Testsignal in Intervallen zu der Steuereinheit auszugeben, um **dadurch** die Fluidtransportvorrichtung (3) intermittierend zu aktivieren, um zu bestimmen, ob das entsprechende Luftströmungssignal vorgegebene Verstopfungsbedingungen erfüllt, und wenn ja, ein Verstopfungssignal auszugeben; und vorzugsweise

bei Empfang eines Verstopfungssignals zu bestimmen, ob das externe Detektionssignal ein vorgegebenes Alarmkriterium für eine offene Kammer, das von dem vorgegebenen Auslösekriterium verschieden ist, erfüllt, und wenn ja, ein Alarmsignal zu erzeugen.

17. Verfahren zum Detektieren eines Feuers in einem überwachten Bereich unter Verwendung eines Feuersensors nach einem der Ansprüche 1 bis 13 oder eines Feuerdetektionssystems nach einem der Ansprüche 14 bis 16, das Folgendes umfasst:

Überwachen (S100) des Vorhandenseins von Feuerprodukten in dem überwachten Bereich unter Verwendung einer externen Detektoranordnung, die dazu ausgelegt ist, ein entsprechendes externes Detektionssignal auszugeben;

Bestimmen (S102), ob das externe Detektionssignal ein vorgegebenes Auslösekriterium erfüllt, und wenn ja, Erzeugen eines Auslösesignals;

bei Auftreten eines Auslösesignals Aktivieren (S104) einer Fluidtransportvorrichtung, um **dadurch** eine Probe der Atmosphäre aus dem überwachten Bereich in eine Kammer zur Analyse (S106) durch eine interne Detektoranordnung, die dazu ausgelegt ist, Feuerprodukte in der Kammer zu detektieren und ein entsprechendes internes Detektionssignal auszugeben, zu saugen;

Bewerten (S108), ob das interne Detektionssignal ein vorgegebenes Alarmkriterium erfüllt, und wenn ja, Erzeugen eines Alarmsignals.

18. Verfahren zum Detektieren eines Feuers in einem

überwachten Bereich nach Anspruch 17, wobei in dem Bewertungsschritt dann, wenn das interne Detektionssignal das vorgegebene Alarmkriterium nicht erfüllt, ein Deaktivierungssignal erzeugt wird (S109), wodurch die Fluidtransportvorrichtung deaktiviert wird.

19. Verfahren zum Detektieren eines Feuers in einem überwachten Bereich nach einem der Ansprüche 17 bis 18, wenn abhängig von Anspruch 7, das ferner das Erzeugen eines Fehlersignals, falls das externe Detektionssignal unter den Hintergrundpegel fällt, umfasst.

20. Verfahren zum Detektieren eines Feuers in einem überwachten Bereich nach einem der Ansprüche 17 bis 19, wenn abhängig von Anspruch 10, das ferner das intermittierende Aktivieren (S112) in Intervallen der Fluidtransportvorrichtung, das Bestimmen, ob das entsprechende Luftströmungssignal vorgegebene Verstopfungsbedingungen erfüllt, und wenn ja, das Ausgeben eines Verstopfungssignals; und vorzugsweise bei Empfang eines Verstopfungssignals das Bestimmen, ob das externe Detektionssignal ein vorgegebenes Alarmkriterium für eine offene Kammer, das von dem vorgegebenen Auslösekriterium verschieden ist, und wenn ja, das Erzeugen eines Alarmsignals umfasst.

Revendications

1. Capteur d'incendie (1) servant à détecter un incendie dans une région sous surveillance (M), le capteur d'incendie (1) comprenant :

une chambre (2) en communication fluidique avec la région sous surveillance (M) par au moins une admission (2a) ;
un ensemble détecteur interne (5) adapté à détecter des produits d'incendie à l'intérieur de la chambre et fournir un signal de détection interne correspondant ;
un ensemble détecteur externe (4) adapté à détecter des produits d'incendie à l'extérieur de la chambre (2) dans la région sous surveillance et fournir un signal de détection externe correspondant ;
un dispositif de transport de fluide (3) adapté à aspirer un échantillon de l'atmosphère de la région sous surveillance dans la chambre par ladite au moins une admission ; et
une unité de commande (6) adaptée à activer le dispositif de transport de fluide (3) dès réception d'un signal de déclenchement fonction du signal de détection externe de manière à aspirer un échantillon de l'atmosphère de la région sous surveillance dans la chambre en vue de son analyse par l'ensemble détecteur interne.

2. Capteur d'incendie (1) selon la revendication 1, comprenant en outre un processeur adapté à établir si le signal de détection externe remplit un critère de déclenchement prédéfini et, le cas échéant, générer le signal de déclenchement.

3. Capteur d'incendie (1) selon la revendication 1 ou la revendication 2, comprenant en outre un processeur adapté à évaluer si le signal de détection interne remplit un critère d'alarme prédéfini et, le cas échéant, générer un signal d'alarme et, de préférence, dans le cas contraire, générer un signal de désactivation de manière à ce que l'unité de commande (6) désactive le dispositif de transport de fluide.

4. Capteur d'incendie (1) selon l'une des revendications précédentes, l'ensemble détecteur interne (5) comprenant l'un des éléments suivantes :

un capteur de diffusion optique, comprenant un émetteur de rayonnement et un détecteur de rayonnement comprenant un émetteur de rayonnement conçu pour émettre un faisceau de rayonnement et un détecteur de rayonnement placé hors du trajet suivi par le faisceau, la réception d'un rayonnement au niveau du détecteur indiquant une diffusion optique due à l'interception du faisceau de rayonnement par des produits d'incendie ;
un capteur de diffusion optique à deux angles, comprenant soit un émetteur de rayonnement et au moins deux détecteurs de rayonnement conçus pour recevoir un rayonnement diffusé suivant des angles différents, soit un détecteur de rayonnement et au moins deux émetteurs de rayonnement conçus pour émettre des faisceaux suivant des angles différents par rapport au détecteur ;
un capteur d'obscurcissement optique ;
un capteur de chaleur ;
un capteur de gaz adapté à détecter un ou plusieurs produits d'incendie gazeux, de préférence du monoxyde de carbone, du dioxyde de carbone, de l'hydrogène ou des oxydes d'azote ; et/ou
un capteur de fumée par ionisation.

5. Capteur d'incendie (1) selon l'une des revendications précédentes, l'ensemble détecteur externe (4) comprenant l'un des éléments suivants :

au moins un capteur de diffusion optique, comprenant un émetteur de rayonnement conçu pour émettre un faisceau de rayonnement suivant un angle prédéfini par rapport au capteur d'incendie et un détecteur de rayonnement pla-

cé hors du trajet suivi par le faisceau, la réception d'un rayonnement au niveau du détecteur indiquant une diffusion optique due à l'interception du faisceau de rayonnement par des produits d'incendie ;
un capteur de gaz adapté à détecter un ou plusieurs produits d'incendie gazeux, de préférence du monoxyde de carbone, du dioxyde de carbone, de l'hydrogène ou des oxydes d'azote ;
un détecteur de flamme, comprenant un détecteur de rayonnement adapté à recevoir un rayonnement thermique émanant de l'intérieur de la région sous surveillance à un domaine de longueurs d'onde prédéfini et un processeur adapté à détecter un papillotement dans le rayonnement reçu indiquant la présence d'une flamme ;
un capteur de chaleur ; et/ou
un détecteur de rayonnement infrarouge.

6. Capteur d'incendie (1) selon la revendication 5, l'ensemble détecteur externe comprenant des premier et deuxième capteurs de diffusion optique, chacun tel que défini dans la revendication 5, le premier capteur de diffusion optique étant conçu pour émettre un faisceau de rayonnement suivant un premier angle prédéfini et le deuxième capteur de diffusion optique étant conçu pour émettre un faisceau de rayonnement suivant un deuxième angle prédéfini plus petit que le premier, de telle sorte que le premier capteur de diffusion optique réagisse à des produits de fumée plus éloignés du capteur d'incendie que du deuxième capteur de diffusion optique.

7. Capteur d'incendie (1) selon la revendication 6, l'émetteur de rayonnement du premier ou du deuxième capteur de diffusion optique étant conçu pour illuminer partiellement le détecteur de rayonnement de l'autre capteur de diffusion optique de telle sorte qu'il détecte un niveau de fond de rayonnement en l'absence de produits d'incendie.

8. Capteur d'incendie (1) selon l'une des revendications précédentes, l'unité de commande (6) étant en outre adaptée à activer par intermittence le dispositif de transport de fluide (3) après réception d'un signal de déclenchement ou d'un signal d'alarme selon un rapport cyclique prédéfini, de préférence un faible rapport cyclique inférieur à 50%, plus préférablement d'environ 25%.

9. Détecteur d'incendie (1) selon l'une des revendications précédentes, la chambre (2) étant pourvue d'une évacuation (2b) permettant à l'échantillon atmosphérique de s'échapper de la chambre vers la région sous surveillance (M), l'évacuation (2b) occupant une position adjacente à l'admission (2a) de manière à établir une circulation de l'atmosphère adjacente au capteur d'incendie (1) dans la région sous surveillance lorsque le dispositif de transport de fluide (3) est activé, de préférence l'admission (2a) comprenant une pluralité de points d'admission entourant l'évacuation (2b) ou l'évacuation comprenant une pluralité de points d'évacuation entourant l'admission (2a) de manière à établir un trajet de circulation sensiblement toroïdal adjacent au capteur d'incendie, la pluralité de points d'admission ou d'évacuation présentant de préférence un agencement annulaire.

10. Capteur d'incendie (1) selon l'une des revendications précédentes, comprenant en outre un capteur d'écoulement d'air (16) adapté à détecter un mouvement de fluide à l'intérieur de la chambre ou entre la chambre et la région sous surveillance et fournir un signal d'écoulement d'air correspondant.

11. Capteur d'incendie (1) selon la revendication 10, comprenant en outre un processeur adapté à appliquer à intervalles réguliers un signal de test à l'unité de commande (6) de manière à activer par intermittence le dispositif de transport de fluide (3) afin d'établir si le signal d'écoulement d'air correspondant remplit des conditions d'obstruction prédéfinies et, le cas échéant, produire un signal d'obstruction.

12. Capteur d'incendie (1) selon la revendication 11, le processeur étant en outre adapté, dès réception d'un signal d'obstruction, à établir si le signal de détection externe remplit un critère d'alarme de chambre ouverte prédéfini, différent du critère de déclenchement prédéfini, et, le cas échéant, générer un signal d'alarme.

13. Capteur d'incendie (1) selon l'une des revendications précédentes, adapté à être monté sur une surface, de préférence un plafond, de la région sous surveillance, le capteur d'incendie comprenant en outre une plaque sensiblement plane (21, 28) adaptée, en service, à coopérer avec la surface et à venir sensiblement à fleur de celle-ci, et placée entre la région sous surveillance (M) et la chambre (2).

14. Système de détection d'incendie, comprenant au moins un capteur d'incendie (1, 20) selon l'une des revendications 1 à 13 et un panneau de commande (30) conçu pour communiquer avec le ou chaque capteur d'incendie (20), le panneau de commande (30) étant adapté à surveiller l'état du ou de chaque capteur d'incendie (20).

15. Système de détection d'incendie selon la revendication 14, le panneau de commande (30) comprenant un processeur (31) adapté, pour le ou chaque capteur d'incendie (20), à :

établir si le signal de détection externe remplit un critère de déclenchement prédéfini et, le cas échéant, générer le signal de déclenchement ; et/ou

évaluer si le signal de détection interne remplit un critère d'alarme prédéfini et, le cas échéant, générer un signal d'alarme et, de préférence, dans le cas contraire, générer un signal de désactivation de manière à ce que l'unité de commande (30) désactive le dispositif de transport de fluide (3).

16. Système de détection d'incendie selon la revendication 14 ou la revendication 15, à condition qu'elles dépendent au moins de la revendication 10, le panneau de commande comprenant en outre un processeur (31) adapté à :

appliquer à intervalles réguliers un signal de test à l'unité de commande de manière à activer par intermittence le dispositif de transport de fluide (3) afin d'établir si le signal d'écoulement d'air correspondant remplit des conditions d'obstruction prédéfinies et, le cas échéant, produire un signal d'obstruction ; et, de préférence,

dès réception d'un signal d'obstruction, établir si le signal de détection externe remplit un critère d'alarme de chambre ouverte prédéfini, différent du critère de déclenchement prédéfini, et, le cas échéant, générer un signal d'alarme.

17. Procédé de détection d'un incendie dans une région sous surveillance au moyen d'un capteur d'incendie selon l'une des revendications 1 à 13 ou d'un système de détection d'incendie selon l'une des revendications 14 à 16, le procédé comprenant les étapes consistant à :

surveiller (S100) la présence éventuelle de produits d'incendie dans la région sous surveillance au moyen d'un ensemble détecteur externe adapté à produire un signal de détection externe correspondant ;

établir (S102) si le signal de détection externe remplit un critère de déclenchement prédéfini et, le cas échéant, générer un signal de déclenchement ;

à l'apparition d'un signal de déclenchement, activer (S104) un dispositif de transport de fluide de manière à aspirer un échantillon de l'atmosphère de la région sous surveillance dans une chambre en vue de son analyse (S106) par un ensemble détecteur interne adapté à détecter des produits d'incendie à l'intérieur de la chambre et produire un signal de détection interne correspondant ;

évaluer (S108) si le signal de détection interne remplit un critère d'alarme prédéfini et, le cas échéant, générer un signal d'alarme.

18. Procédé de détection d'un incendie dans une région sous surveillance selon la revendication 17, l'étape consistant à évaluer si le signal de détection interne remplit un critère d'alarme prédéfini comprenant en outre, si le signal de détection interne ne remplit pas le critère d'alarme prédéfini, l'étape consistant à générer (S109) un signal de désactivation de manière à désactiver le dispositif de transport de fluide.

19. Procédé de détection d'un incendie dans une région sous surveillance selon l'une des revendications 17 et 18 à condition qu'elles dépendent de la revendication 7, comprenant en outre l'étape consistant à générer un signal de panne si le signal de détection externe passe en dessous du niveau de fond.

20. Procédé de détection d'un incendie dans une région sous surveillance selon l'une des revendications 17 à 19 à condition qu'elles dépendent de la revendication 10, comprenant en outre les étapes consistant à activer par intermittence (SI12) à intervalles réguliers le dispositif de transport de fluide, établir si le signal d'écoulement d'air correspondant remplit des conditions d'obstruction prédéfinies et, le cas échéant, produire un signal d'obstruction ; et, de préférence,

dès réception d'un signal d'obstruction, établir si le signal de détection externe remplit un critère d'alarme de chambre ouverte prédéfini, différent du critère de déclenchement prédéfini, et, le cas échéant, générer un signal d'alarme.

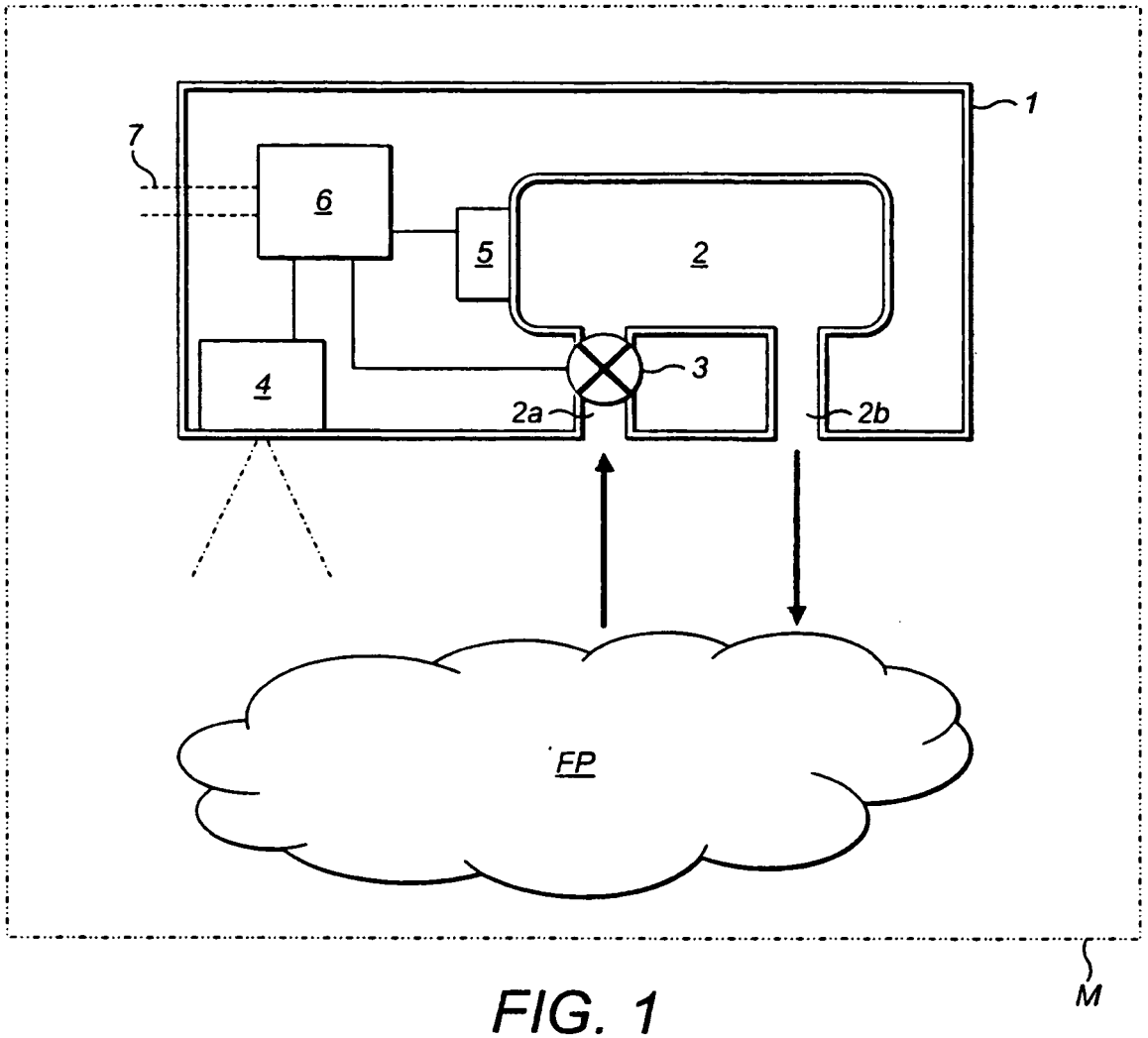


FIG. 1

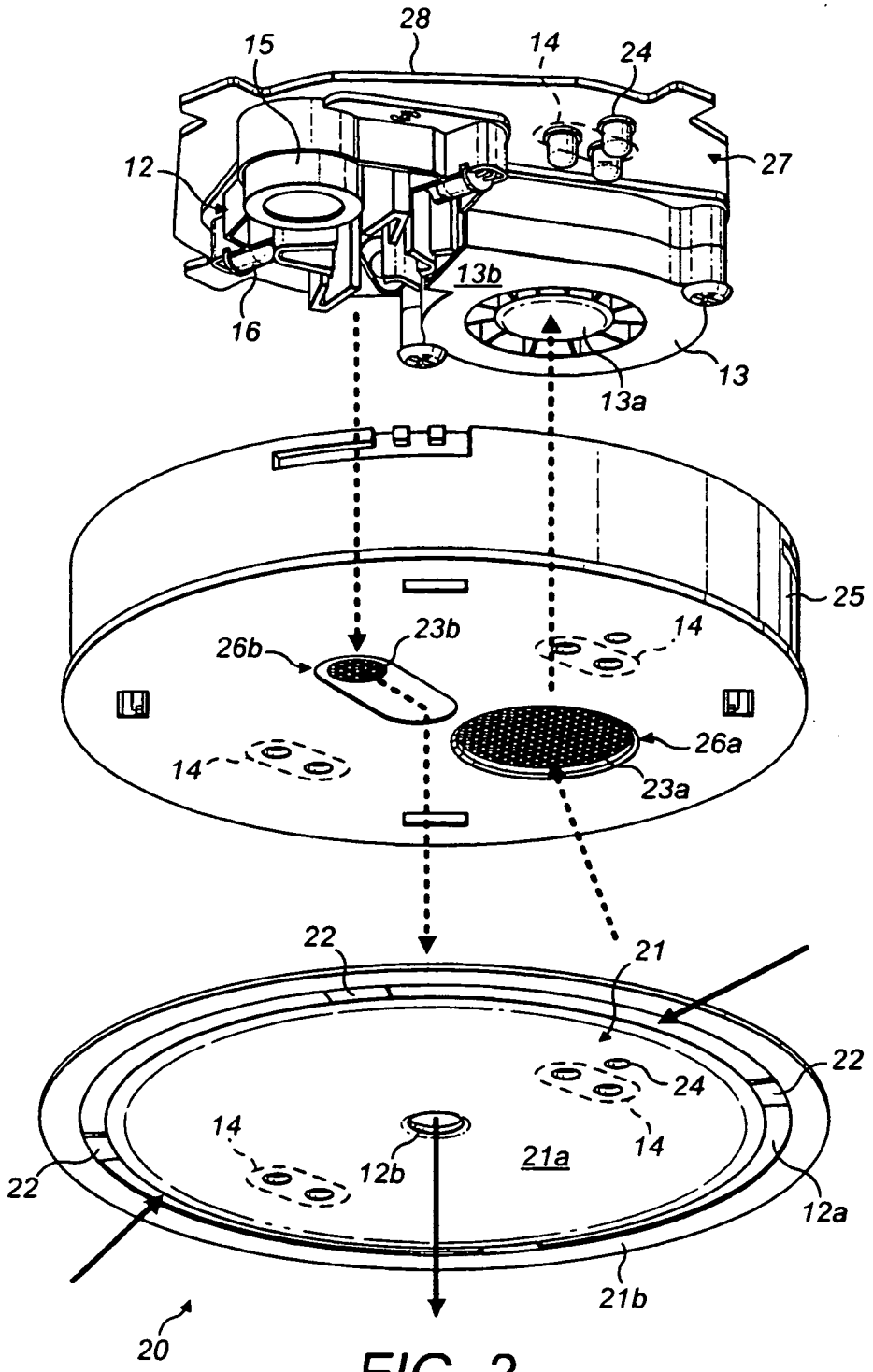

28
15
14
24
12
27
13b
16
13
13a
25
26b
23b
14
14
26a
23a
22
21
22
24
14
14
12b
21a
22
12a
21b
20

FIG. 2

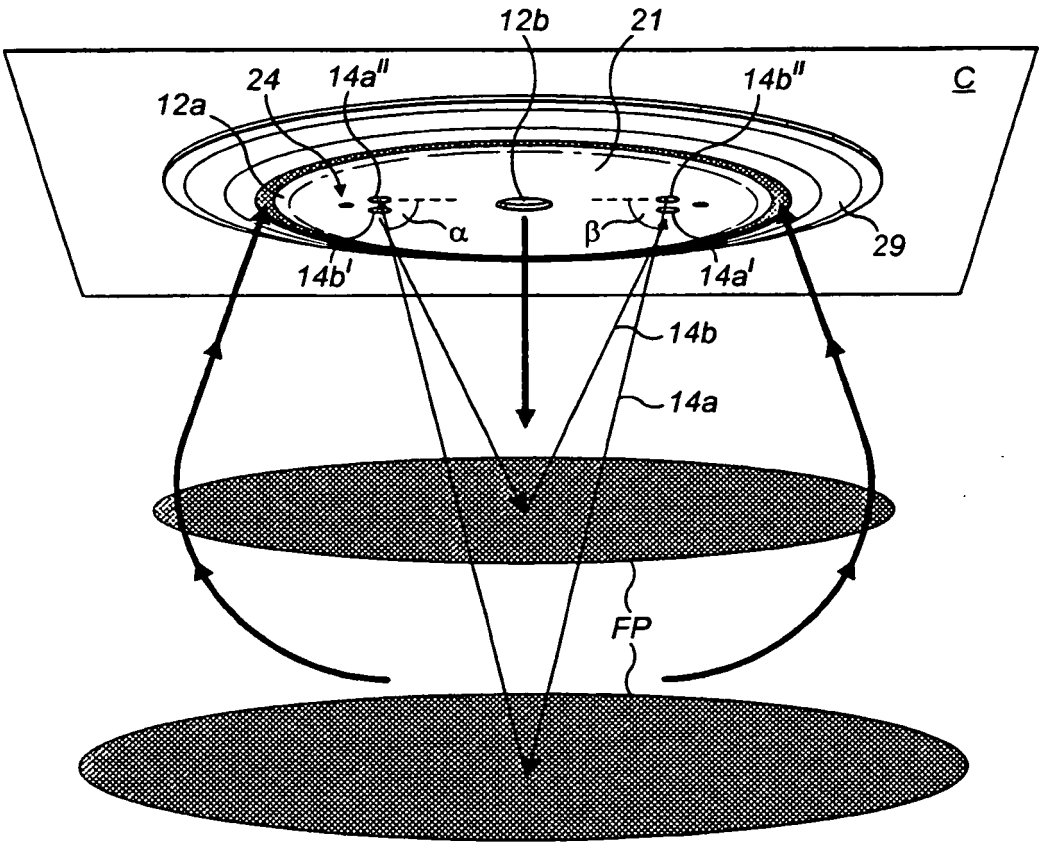


FIG. 3

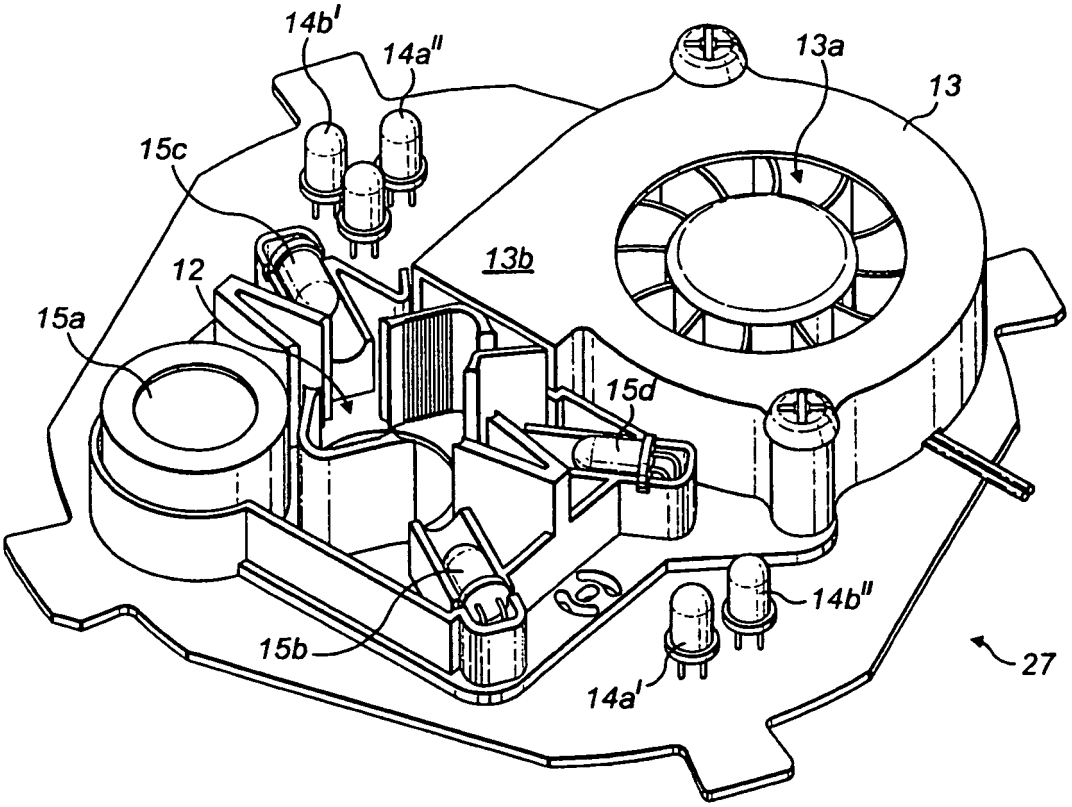

14b'
14a''
13a
13
15c
13b
12
15a
15d
14b''
15b
14a'
27

FIG. 4

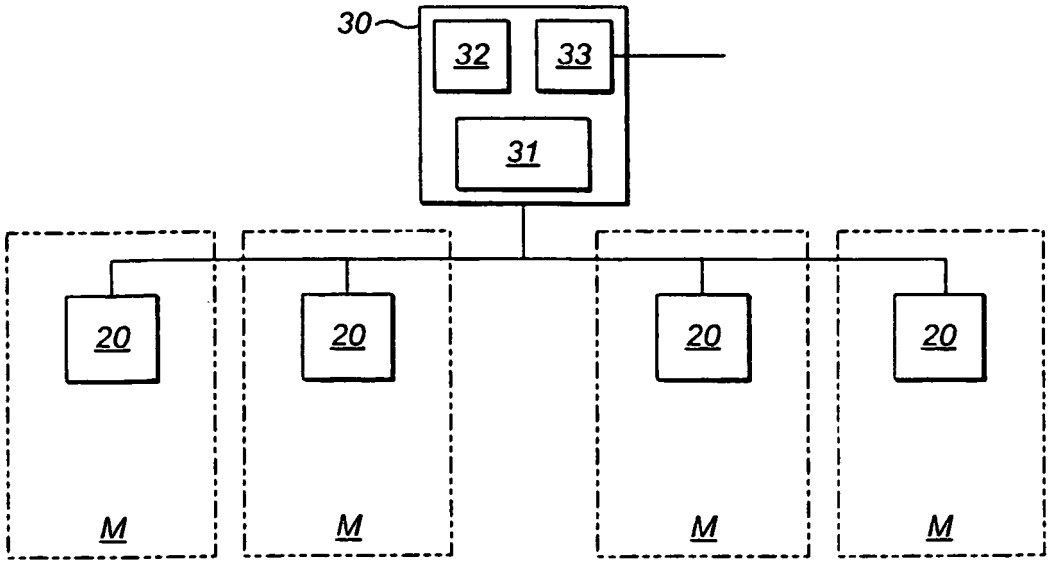

30
32
33
31
20
20
20
20
M
M
M
M

FIG. 5

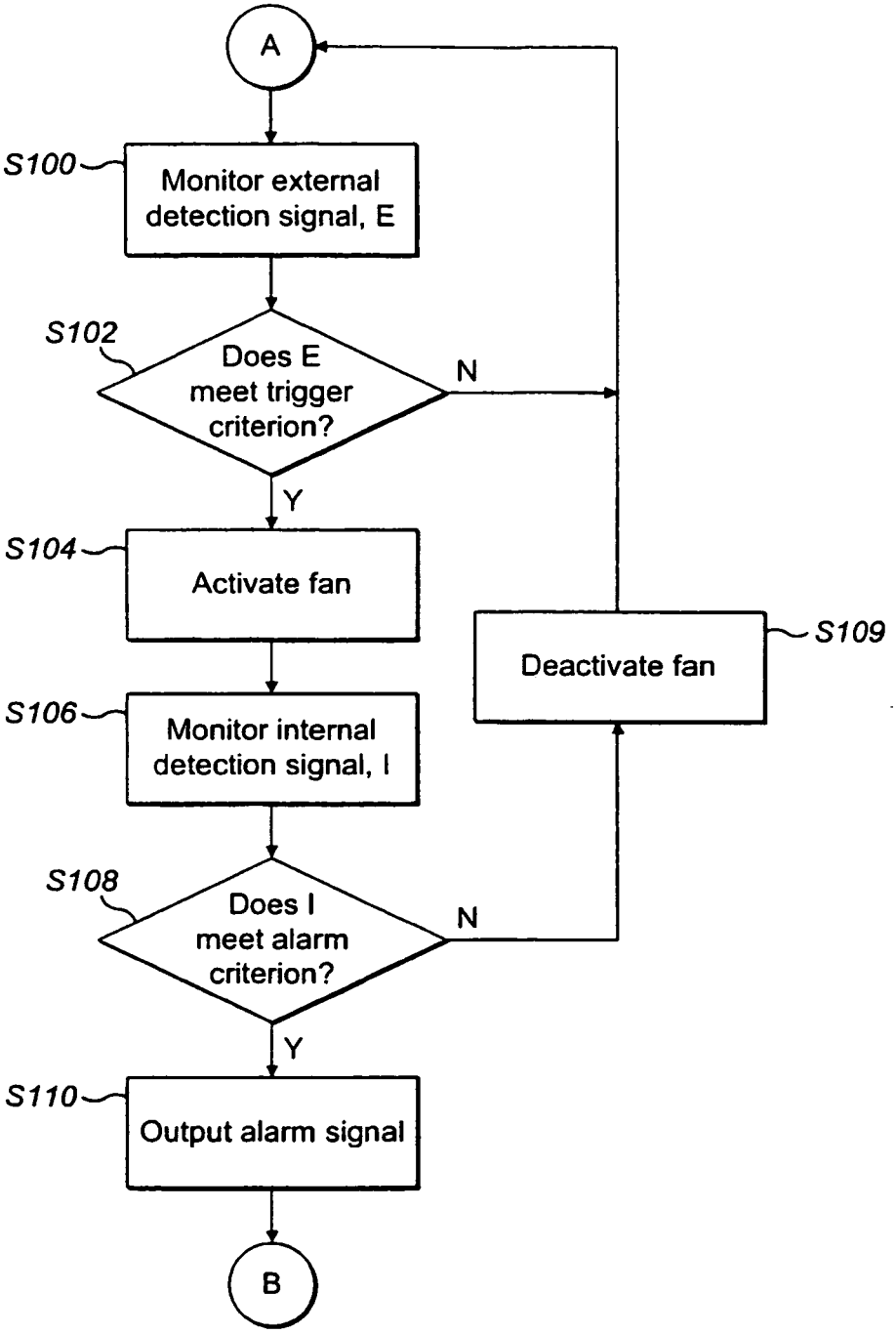

A
S100
Monitor external detection signal, E
S102
Does E meet trigger criterion?
N
Y
S104
Activate fan
S106
Monitor internal detection signal, I
S108
Does I meet alarm criterion?
N
Y
S110
Output alarm signal
B
S109
Deactivate fan

FIG. 6

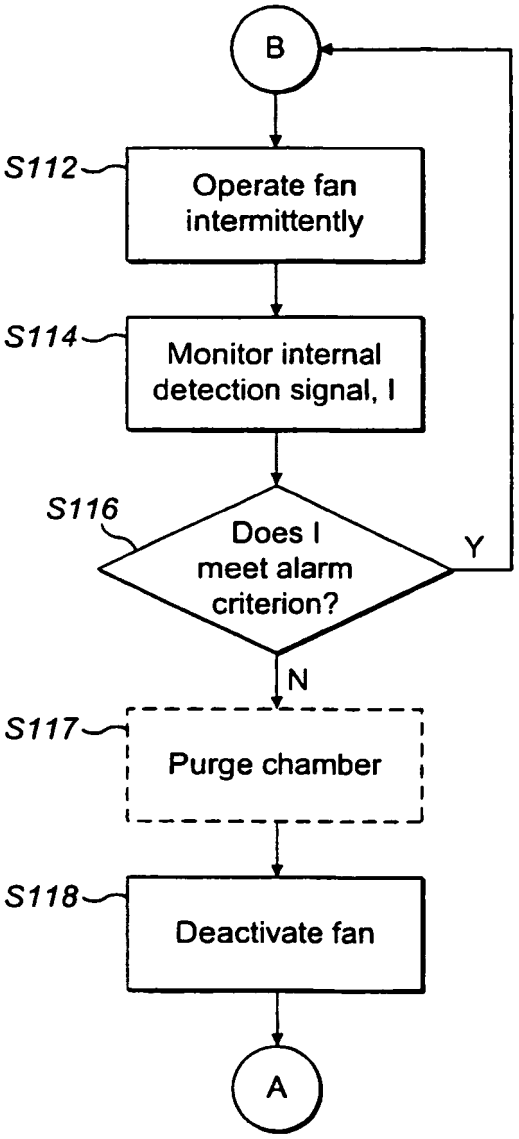

B
S112
Operate fan intermittently
S114
Monitor internal detection signal, I
S116
Does I meet alarm criterion?
Y
N
S117
Purge chamber
S118
Deactivate fan
A

FIG. 7

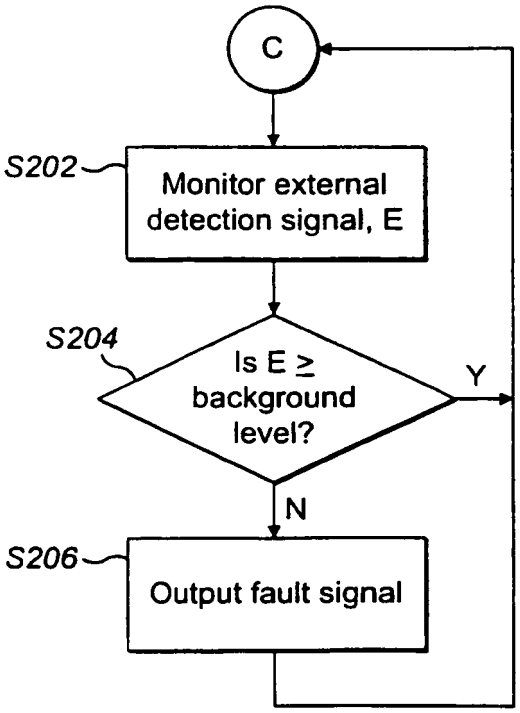

C
S202
Monitor external detection signal, E
S204
Is E ≥ background level?
Y
N
S206
Output fault signal

FIG. 8

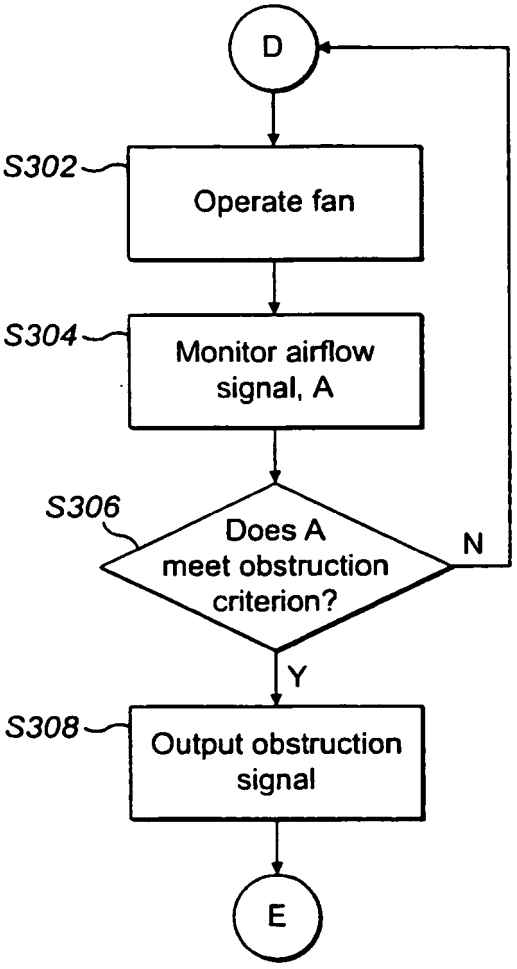

D
S302
Operate fan
S304
Monitor airflow signal, A
S306
Does A meet obstruction criterion?
N
Y
S308
Output obstruction signal
E

FIG. 9

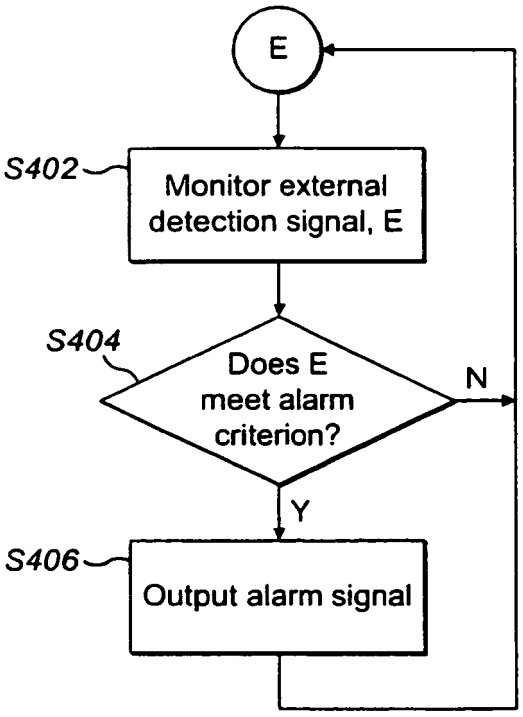

E
S402
Monitor external detection signal, E
S404
Does E meet alarm criterion?
N
Y
S406
Output alarm signal

FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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