May 14, 1968 G. A. ROBERTS 3,383,670

SMOKE AND HEAT DETECTION UNIT

Filed July 13, 1964 2 Sheets-Sheet 1

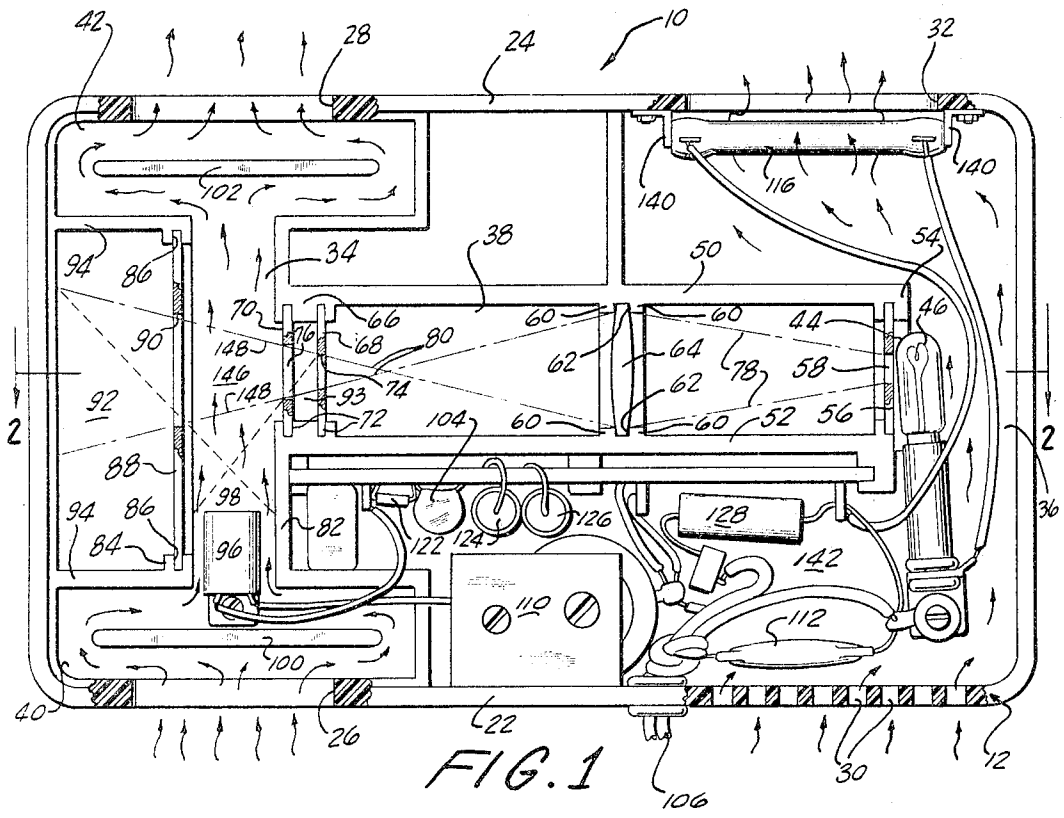

FIG. 1

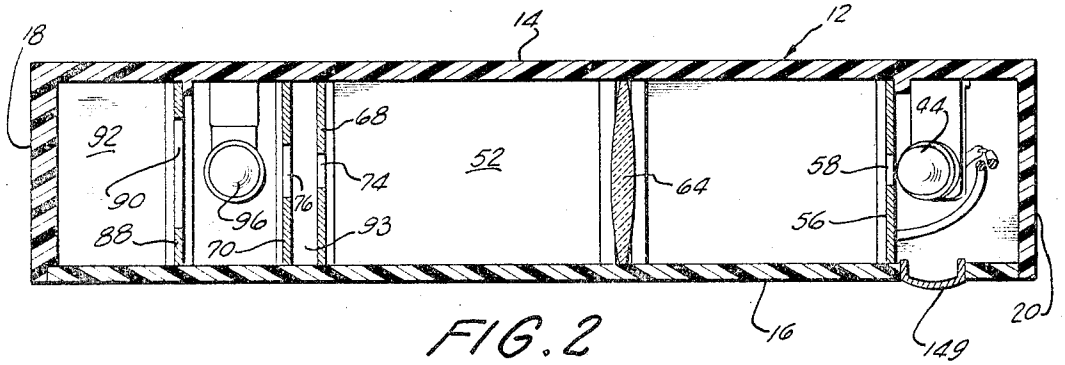

FIG. 2

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SMOKE AND HEAT DETECTION UNIT

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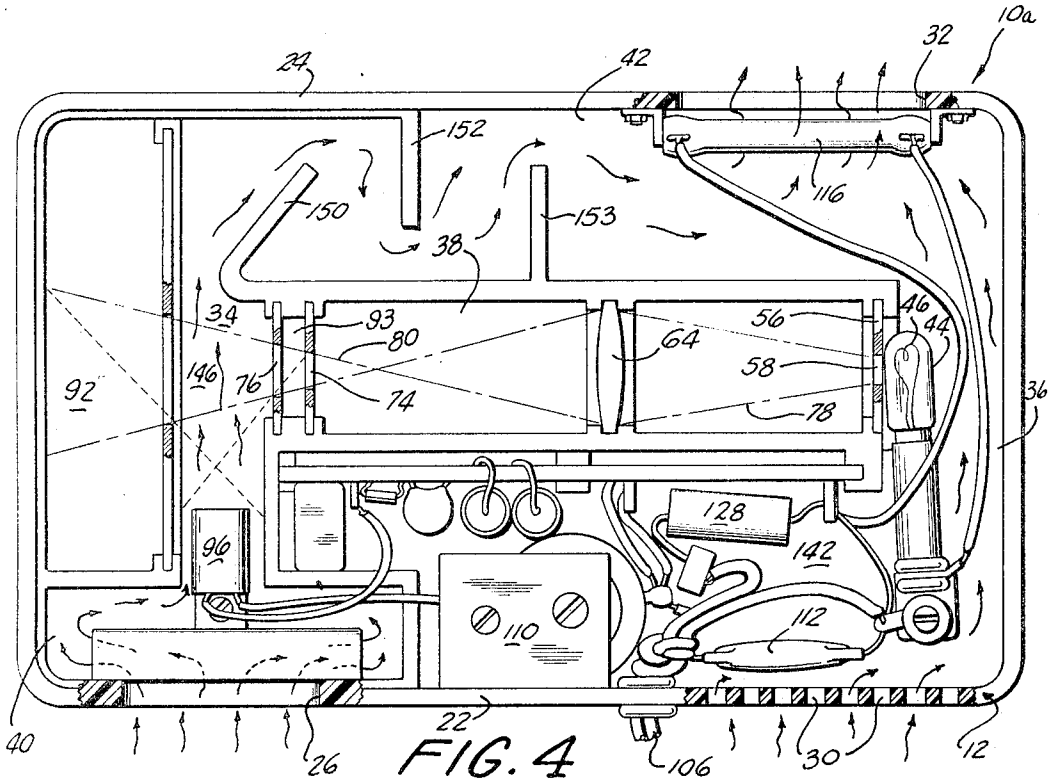

FIG. 4

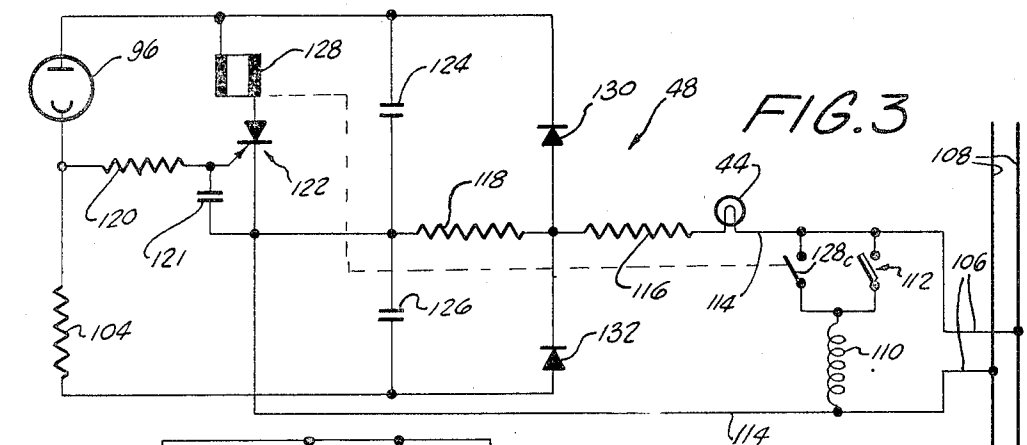

FIG. 3

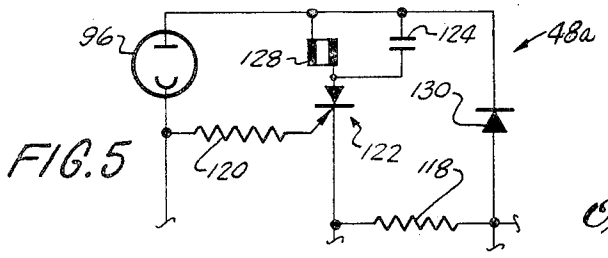

FIG. 5

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SMOKE AND HEAT DETECTION UNIT

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11 Claims. (Cl. 340—237)

ABSTRACT OF THE DISCLOSURE

A unit for detecting the presence of suspended matter such as smoke in the air in which a casing is provided with partitions that form an upright detection compartment, light traps at the ends of the detection compartment, a light transmission conduit which is perpendicular to the detection compartment and is positioned on one side of the detection compartment, and a light receptacle which is positioned on the opposite side of the detection compartment. Aperture plates are mounted on the partitions so as to communicate the light transmission conduit and the receptacle with the detection compartment. A light energy source and a lens in the light transmission conduit cooperate to provide for the transmission of light into the detection compartment so as to form a light interaction region therein. A light detecting photocell is positioned within the compartment to one side of the light interaction region. Light from the energy source is focused by the lens within an orifice formed in a plate disposed within the light transmission conduit so as to concentrate the light in the interaction region of the detection compartment and thereby to at all times maintain a low background light level at the detector.

This invention relates generally to fire detecting apparatus and more particularly to an improved unit for detecting and signaling the existence of smoke or heat in room air above a predetermined safe level.

Since many serious fires in homes and commercial establishments are attended with significant amounts of smoke before the fire becomes unmanageable, the desirability of a compact and economical unit which will detect and signal the existence of abnormal smoke in the air is acknowledged. Oftentimes, the best early warning of a fire is the presence of an abnormal amount of smoke. Such a unit may also be adapted to the detection of dust, water, or other air contamination. In such a unit, it is also desirable to provide for detection of abnormal heat to insure detection of any fire which does not involve significant amounts of smoke. It is an object of this invention, therefore, to provide an improved unit for detecting and signaling the existence of smoke or heat which is readily installed by plugging into an electrical outlet, is compact and economical, is quickly triggered by smoke particles in the air, includes an alarm circuit which is unaffected by variations in voltage supply, and is easily reset following actuation.

In the unit of this invention, a light tight casing having openings through which room air can flow, is provided with a light source. A light interaction region is provided in the casing through which light from the source is directed and through which room air flows. A light sensitive detector, connected to an alarm circuit, is positioned at one side of the light interaction region so that only small amounts of externally or internally originating light normally fall on the detector. The intensity of this small amount of light on the detector is insufficient to trigger the alarm circuit. However, when abnormal amounts of particles, such as smoke particles, are present in the air flowing through the light interaction region of the casing, light within said region will be reflected from these particles onto the detector which will in turn trigger the alarm

circuit to signal the existence of smoke in the air. The unit is readily installed by merely plugging a cord connected to the alarm circuit into an electrical outlet, and is readily reset after it has been actuated by momentarily unplugging the cord.

Further objects, features and advantages of this invention will become apparent from a consideration of the following description, the appended claims and the accompanying drawing in which:

FIGURE 1 is an elevational view of the detector unit of this invention, with the front wall of the casing removed for the purpose of clarity;

FIGURE 2 is a transverse sectional view of the unit of this invention looking substantially along the line 2—2 in FIG. 1;

FIGURE 3 is a diagrammatic illustration of the alarm circuit which forms a part of the detector unit of this invention;

FIGURE 4 is an elevational view, similar to FIG. 1, of a modified form of the detector unit of this invention; and

FIGURE 5 is a fragmentary diagrammatic illustration of a modified form of alarm circuit, illustrated similarly to FIG. 3 and showing the only portion of the modified circuit which is different than the circuit shown in FIG. 3.

With reference to the drawing, the detector unit of this invention, indicated generally at **10**, consists of a casing **12**, preferably formed of a lightweight plastic, having a back wall **14**, a front wall **16**, end walls **18** and **20**, a bottom wall **22** and a top wall **24**. An inlet opening **26** for room air is formed in the bottom wall **22** and an outlet opening **28** for this air is formed in the top wall **24**. A plurality of openings **30** are also formed in the bottom wall **22** for the purpose of admitting cooling air to the interior of the casing **12**. This cooling air flows out of the casing through an opening **32** formed in the top wall **24** at a position spaced from the outlet opening **28**.

Partitions in the casing **12** define a particle detection chamber or compartment **34**, a light chamber **36**, a light transmission conduit **38**, a lower light trap **40** and an upper light trap **42**. An incandescent lamp **44**, having a filament **46**, is positioned in the light chamber **36** and connected in the circuit shown in FIG. 3 and indicated generally at **48**. The light transmission conduit **38** is substantially horizontal and is defined by upper and lower spaced partitions **50** and **52**, respectively, which extend between the front and back walls **14** and **16** of the casing **12**.

The inlet end **54** of the conduit **38** has an orifice plate **56** removably positioned therein and provided with an orifice **58** of predetermined size positioned adjacent the lamp **44**. Intermediate its ends, the conduit **38** is formed with pairs of vertically extending projections **60** which form spaced tracks **62** in which a lens **64** is removably positioned. At its outlet end **66**, the conduit **38** has an orifice plate **68** and an aperture plate **70** removably mounted therein. The plates **68** and **70** are mounted in slots **72** formed in the partitions **50** and **52**. The plate **68** has an orifice **74** of predetermined size which is substantially horizontally aligned with an aperture **76** formed in the plate **70**.

The lens **64** is shaped so that it will project an image of a portion of the lamp filament **46** at a position in the plane of the orifice plate **68**. In other words, the orifice plates **56** and **68** are positioned relative to the lens **64** such that a light beam **78** from lamp **44** enters the conduit **38** through the orifice **58** and falls on the lens **64**. The lens **64** projects the beam **78** through the orifice **74** so that the main energy of the light beam **78** is concentrated in an image of the filament **46** located in the orifice **74**. This arrangement minimizes the area of orifice **74** to reduce energy from light sources other than the lens **64** while still utilizing the maximum light beam energy.

The light beam 80 passing through the orifice 74 spreads out in a conical shape as shown in FIG. 1 and passes through the aperture 76 so that it travels transversely across the vertically extending light detection chamber 34 for a purpose to appear presently. As shown in FIG. 1, the aperture 76 is located intermediate the upper and lower ends of the chamber 34 which is defined by vertically extending partitions 82 and 84. Slots 86 in the partition 84 slidably support an aperture plate 88 having an aperture 90 which is larger than and substantially vertically aligned with the aperture 76. As a result, the light beam 80 passing through the chamber 34 flows through the aperture 90 into a receptacle 92 formed in the casing 12 by the aperture plate 88 and horizontal partitions 94. Any light reflected back through aperture 76 falls in the space or receptacle 93 formed between the plates 65 and 70. The walls of the receptacles 92 and 93 are preferably blackened to minimize light reflection.

A photosensitive cell 96, which in the illustrated embodiment of the invention is a photoconductive cell, is mounted on the casing 12 adjacent the lower end of the light detection chamber 34 and positioned relative to the apertures 76 and 90 such that substantially all reflected and scattered light, almost all of which will be above the broken lines 98 due to the locations of the apertures 76 and 90, passing through the apertures 76 and 90, will not strike the cell 96. A small amount of this scattered and reflected light will reflect off the partition 82 and plate 88 and impinge on the cell 96 and this is advantageous in this invention as will more clearly appear hereinafter. A light baffle or partition 100 in the light trap 40, and a similar light baffle or partition 102 in the trap 42, prevent the entry of substantial amounts of outside light into the upright detection chamber 34.

The photocell 96 is connected in series with a resistor 104 in the circuit 48, and in the circuit 48 the cell 96 also functions as a resistor since, for a given voltage, the curren which can flow through it is proportional to the intensity of light impinging on the cell 96. Current is supplied to the cell 96 by plugging a cord 106 into an electrical outlet connected to the usual alternating current supply 108. A buzzer 110, or equivalent electrically actuated signal means of any desired kind, is connected in series with a conventional temperature sensitive switch 112 and the buzzer 110 and switch 112 are connected across conductors 114 which are connected to the cord wires 106. A resistor dropping network consisting of resistors 116, 118 and lamp 44 are connected in series in the circuit 48 to reduce the line voltage to a level compatible with a silicon controlled switch 122.

The circuit 48 consists essentially of a bridge circuit with a triggered relay as the bridge detector. Two legs of the bridge are proportionately related DC sources, namely, condensers 124 and 126, which in this embodiment of the invention are substantially equal in magnitude and are thus balanced. The other two bridge legs are the cell 96, which is a variable resistor, and the fixed set point resistor 104. A diode 130 rectifies the AC voltage across the resistor 118 to produce a DC voltage across the condenser 124. A second diode 132 rectifies the AC voltage across the resistor 118 to produce a DC voltage across the condenser 126 of opposite polarity. The voltages across the condensers 124 and 126 are proportionately related.

The AC source 108, in combination with the resistors 116, 118 and lamp 44, the rectifying diodes 130 and 132, and the capacitors 124 and 126 provides for proportional DC voltages of opposite polarity across the capacitors 124 and 126. As a result, when the light on cell 96 has increased to a level at which the resistance of cell 96 bears a predetermined relationship, which in this embodiment is substantially equality, to the resistance of fixed resistor 104, sufficient current can flow through silicon controlled switch 122 to provide for energizing of a relay 128 in series therewith and a consequent closing of normally open contacts 128c. The contacts 128c are connected in parallel with the temperature switch 112.

A capacitor 121 connected in parallel with the switch 122 functions as a filter to reduce the possibility of false actuation of the switch 122 due to sharp wave front pulses in the circuit 48 which could otherwise provide for operation of buzzer 110 at times other than when intended.

It can thus be seen that if the resistance of cell 96 is reduced, in response to an increase in the light intensity impinging thereon, the relay 128 is actuated to close the contacts 128c energizing the buzzer 110. Thereafter, if the light intensity on the cell 96 is reduced to such a value that resistance of the cell 96 is increased to a value greater than the resistance of the resistor 104, the buzzer 110 will continue operation. To reset the circuit 48, the current through the silicon controlled switch 122 must be reduced below its holding value. As the circuit 48 is illustrated, this is accomplished by disconnecting the cord 106 from the wall outlet.

In FIG. 5, a modified form of the control circuit 48 is shown and indicated generally by the numeral 48a. The circuit 48a is identical to the circuit 48 without switch 125 except for the connection of capacitor 124 to the anode of silicon controlled switch 122 in the circuit 48a, instead of the cathode of switch 122 as in the circuit 48. The capacitor 121 is also deleted in circuit 48a because it is unnecessary. In all other respects circuits 48 and 48a are identical. The circuit 48a is utilized when automatic resetting of the alarm circuit is desired when smoke has abated, without having to disconnect cord 106. When detector unit 10 is used with circuit 48a installed, operation of buzzer 110 is automatically discontinued when the situation which caused actuation of relay winding 128 has changed to normal.

In the circuit 48a, the output of diode 130 constitutes a switched DC source, so that the anode voltage to switch 122 varies. At least at one point of time in each powerline cycle the output coltage of diode 130 is proportionately related in magnitude to the relatively constant voltage across capacitor 126. At such time, if the magnitude of resistance of cell 96 has the proper relationship to the fixed resistance 104, in this embodiment substantially equality, the switch 122 is triggered to provide for energizing of relay 128. As soon as this situation returns to normal, in this embodiment as soon as the resistance of cell 96 is increased substantially above the value of resistance 104, current flow through switch 122 ceases so that capacitor 124 is no longer being charged. Consequently, as soon as capacitor 124 has become discharged, relay 128 becomes de-energized so that contacts 128c open and the warning buzzer ceases operating. The circuit 48a is then conditioned for subsequent operation.

As shown in FIG. 1, means are provided to cause a flow of air inwardly of the casing through the openings 30 around the heat sensing switch 112, lamp 44 and the resistor 116 so as to cool the lamp and resistor and bring room air into contact with heat switch 112. In this embodiment of the invention this means consists in mounting the resistor 116 on brackets 140 secured to the casing top wall 24 at a position within the casing and adjacent the outlet opening 32 so that heat from the resistor 116 and the lamp 44 will cause a convection flow of air. The components of the circuit 48, other than the lamp 44 and the resistor 116 are mounted in a compartment 142 formed in the casing below the light conduit wall 52 in communication with the light chamber 36 to provide for a compact package in a casing 12 of minimum size.

In the operation of the unit 10, the casing 12 is mounted on a wall or the like in a building such as a home, and the cord 106 is plugged into a wall outlet adjacent the casing 12. This causes the light source, in this case the lamp filament 46, to glow and project the light beam 70 onto the lens 64. The lens 64 projects this beam of light toward the orifice plate 68 so that an image of the light source 46 is formed at the orifice 74 and a diverging beam of light 80 is projected across the detection chamber 34. This forms a light interaction region 146 in the

chamber 34 located between the apertures 76 and 90 and between the upper and lower boundaries 148 of the beam 80. The normal flow of air in the room or building causes a flow of air through the chamber 34 and if the particle content of this air is normal, the amount of light reflected from the particles in the air on the cell 96 is insufficient to lower the electrical resistance of the cell 96 sufficiently to trigger the switch 122.

A glass or plastic window 149 in the casing front wall 16 at a position in horizontal alignment with the lamp 44 provides a visual indication that the lamp 44 is energized and that the unit 10 is operative. In the event of smoke in the air flowing through the chamber 34, the light is reflected onto the cell 96 from the smoke particles as they flow through the interaction region 146 thereby lowering the resistance of the cell 96 sufficiently to cause the silicon control switch 122 to actuate the relay winding 128. The alarm signal, in this case the buzzer 110, is then actuated to indicate the existence of smoke. The cavities 92 and 93 minimize and control the adverse effect of scattered and reflected external and internal light on the cell 96. However, some scattered and reflected light does impinge on the cell 96 to thereby maintain it in a partially excited condition at all times. This is advantageous because in the event of smoke in the interaction region 146, so that the light intensity on the cell 96 is increased, the time required for the cell 96 to actuate the alarm circuit 48 is reduced.

A modified form of the unit 10 is illustrated in FIG. 4 and indicated generally at 10*a*. The unit 10*a* is identical in many respects to the unit 10 so that like numerals are used on the unit 10*a* to indicate like parts on the unit 10. The unit 10*a* differs from the unit 10 only in the form of the light trap 42. In the unit 10*a* the wall opening 28 is eliminated and the air flowing through the detection chamber 34 for detection purposes is directed out of the casing 12 through the opening 32 for room air. Spaced baffles 150 and 153 project into the light trap 42 from the inner wall thereof and a baffle 152 projects into the light trap 42 from the outer wall thereof at a position between baffles 150 and 153. All of the baffles are located between the opening 32 and the outlet end of the smoke detection chamber 34 so that external light entering the chamber 34 is reduced, and the air flowing through the chamber 34 follows a circuitous path through the trap 42 to the outlet opening 32. This flow of air is, in this embodiment, aided by heat from the resistor 116 which improves the convection flow of air through the chamber 34. In all other respects, the unit 10*a* is identical to the unit 10.

From the above description, it is seen that this invention provides an improved smoke and fire detector unit 10 which, by virtue of the arrangement of the lamp 44, the light transmission conduit 38, the smoke detector chamber 34 and the photocell 96 can be arranged in a compact casing 12. The arrangement of the elements in the light transmission conduit 38 and the photocell 96 provides for a maximum utilization of light energy from the lamp 44 to actuate the cell 96 with a minimum time lapse so that a sensitive unit 12 is provided. The construction of the casing 12 with integral partitions, such as the partition or walls 50, 52, 82, 84, 100 and 102 enables economical one-piece molding of the casing from materials such as plastic. Flow of room air to chamber 34 is provided, and an arrangement of the casing 12 so that chamber 34 is upright with the openings 26 and 28 at the bottom and top ends of the chamber is preferred since this arrangement optimizes flow. Also, the formation of the orifices 58 and 74 and the apertures 76 and 90 in plates which are separately inserted in the casing 12 enables the use of very thin wall insert plates thereby reducing to a minimum light reflection from the edges of the orifices and apertures. Further, the particular arrangements and circuitry herein contemplated are of such simplicity, but yet stability, that a device is provided having a maximum degree of reliability at a minimum cost for both manufacture and maintenance.

It will be understood that the smoke and heat detector unit which is herein disclosed and described is presented for purposes of explanation and illustration and is not intended to indicate limits of the invention, the scope of which is defined by the following claims.

What is claimed is:

1. In a unit for detecting the presence of suspended matter, such as smoke, in the air; a light energy source, means forming a detection compartment having a light interaction region therein, means forming an orifice to one side of said interaction region, said orifice being located between said light energy source and said interaction region, an optical system operable to direct a light beam from said source so as to focus light energy from said light source substantially at and within said orifice and to one side of said interaction region, and light detection means located on one transverse side of said beam and positioned in communication with said compartment to receive energy from said interaction region.

2. A unit according to claim 1 further including means forming substantial aligned light transmission apertures on opposite sides of the compartment and to one side of the light detection means, the apertures being located with respect to the light energy source to provide for the transmission of said beam through the apertures and across the compartment at a position to one side of the light detection means to form the light interaction region.

3. A unit according to claim 2 further including means forming a light chamber containing said light energy source, a casing containing said compartment and chamber, an electrical resistor positioned in the casing, the casing having at least one air inlet opening and at least one air outlet opening located adjacent the resistor so that heat from the resistor promotes the flow of air through the casing.

4. A unit according to claim 3 in which said one air inlet opening and said one air outlet opening communicate with said light chamber and in which said casing has a second air inlet opening and a second air outlet opening which communicate with said detection compartment.

5. A unit according to claim 1 further including signal means operatively associated with the light detection means so that the signal means is triggered in response to subjection of the light detection means to a predetermined light intensity, and means shielding the light detection means from direct and indirect rays of light from the source of an intensity equal to said predetermined intensity in the absence of a predetermined amount of suspended particles in the air in said interaction region.

6. A unit according to claim 1 further including means forming an aperture of predetermined size on one side of said compartment, means forming a receptacle communicating with the aperture for receiving light passing therethrough from the interaction region, said light detection means being located with respect to said aperture, said orifice, and said receptacle such that in the absence of a predetermined concentration of suspended matter in the interaction region the intensity of the light falling on said light detection means is below a predetermined intensity.

7. A unit according to claim 1 in which the light detection means is a photoconductive photocell disposed in the detection compartment so that light reflected on to the cell from the light interaction region lowers the electrical resistance of the cell, a signal circuit including said cell and said light energy source, conductor means in said circuit adapted to be connected to a source of AC voltage, a fixed resistance resistor connected in the circuit, capacitor means connected in the circuit so as to form with said cell and said resistor a four leg bridge in which said cell and said resistor form adjacent legs of the bridge, the other adjacent two legs of said bridge being

formed by said capacitor means which constitute proportionately related DC voltage sources of opposite polarity, a detector branch in the bridge having a silicon controlled switch therein, said branch being connected at one end between the resistor and the photocell and at the opposite end between the DC voltage sources so that an actuating current will flow through the detector branch when the resistance of the cell falls below a predetermined proportional value of the resistance of the resistor, and signal means in said circuit actuatable in response to flow of actuating current through the detector branch.

8. A unit for detecting the presence of suspended matter, such as smoke, in the air comprising:

a casing having a pair of spaced front and back walls,

partition means in said casing extending across the space between said walls,

said partition means forming in said casing an elongated detection compartment having a pair of open ends and an open side, an elongated light transmission conduit substantially perpendicular to said detection compartment and having a pair of ends one of which is open and communicates with said detection compartment, light baffles in said casing adjacent to and spaced from said detection compartment ends, and a light receptacle having an open side in communication with said open side of said detection compartment,

a first aperture plate mounted on said partition means so as to form said open side of said detection compartment and said side of said light receptacle,

a second aperture plate mounted on said partition means at said one end of said light transmission conduit,

a lens mounted on said partition means and positioned between the ends of said light transmission conduit,

a light source in said casing at the opposite one of said pair of ends of said light transmission conduit,

light sensitive means in said compartment,

and means forming air inlet and outlet openings in said casing adjacent said baffles and communicating with said detection compartment.

9. A unit according to claim 8 wherein track means are formed on said partition means, said aperture plates are rectangular, and each said aperture plate has a pair of opposite edges thereof supported on said track means.

10. A unit for detecting the presence of suspended matter, such as smoke, in the air comprising:

a casing having a pair of spaced front and back walls,

a plurality of partitions in said casing extending across the space between said walls,

said partitions forming in said casing an elongated detection compartment having a pair of open ends and an open side, a light transmission conduit substantially perpendicular to said detection compartment and having a pair of ends one of which is open and communicates with said detection compartment, and a light receptacle having an open side in communication with said open side of said detection compartment,

a first aperture plate mounted on a first substantially parallel pair of said partitions so as to form said open side of said detection compartment and said side of said light receptacle,

a second aperture plate mounted on a second substantially parallel pair of said partitions at said one end of said light transmission conduit,

a lens mounted on said second pair of said partitions and positioned between the ends of said light transmission conduit,

a light source in said casing at the opposite end of said light transmission conduit,

light sensitive means in said compartment, and means forming air inlet and outlet openings in said casing communicating with said open ends of said detection compartment.

11. A unit for detecting the presence of suspended matter, such as smoke, in the air comprising:

a casing having a pair of spaced front and back walls,

a plurality of partitions in said casing extending across the space between said walls,

said partitions forming in said casing an elongated detection compartment having a pair of open ends and an open side, light traps at said ends of the detection compartment extending substantially perpendicularly thereof, an elongated light transmission conduit extending substantially perpendicular to said detection compartment and having a pair of ends one of which is open and communicates with said detection compartment intermediate the ends thereof, light baffles in said light traps substantially perpendicular to said detection compartment, and a light receptacle disposed between said light traps and having an open side in communication with said open side of said detection compartment,

a first aperture plate mounted on a first substantially parallel pair of said partitions so as to form said open side of said detection compartment and said side of said light receptacle,

a second aperture plate mounted on a second substantially parallel pair of said partitions at said one end of said light transmission conduit,

a lens mounted on said second pair of said partitions and positioned between the ends of said light transmission conduit,

a light source in said casing at the opposite end of said light transmission conduit,

light sensitive means in said compartment, and

means forming air inlet and outlet openings in said casing communicating with said open ends of said detection compartment.

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