

[54] **PHOTOELECTRIC DETECTOR WITH COMPENSATING PHOTOCELL**

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[52] U.S. Cl.250/218, 250/239, 356/207, 340/237

[51] Int. Cl.G01n 21/26

[58] Field of Search.250/218, 216, 210, 239, 217 SS; 356/207, 208

[56] **References Cited**

UNITED STATES PATENTS

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3,365,661	1/1968	Wereb, Jr.....	250/210 X

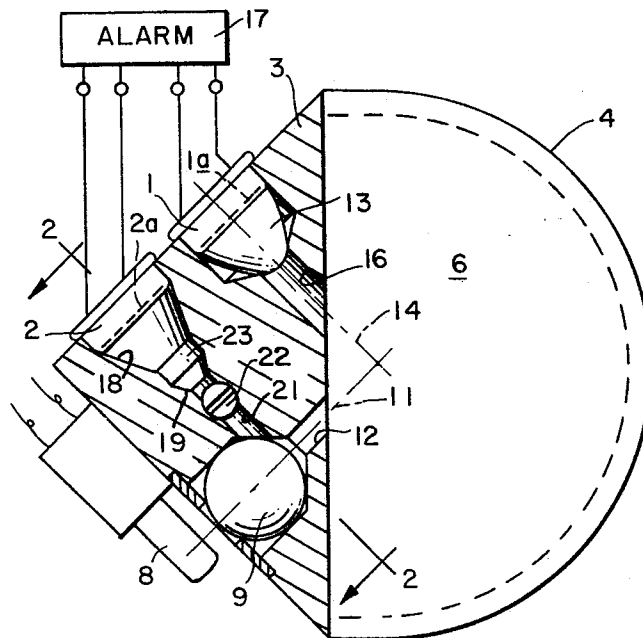
3,505,529	4/1970	Moore.....	250/218
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2,967,946	1/1961	Leisey.....	250/218
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3,439,178	4/1969	Rottmann.....	250/223 X
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Primary Examiner—Walter Stolwein
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[57] **ABSTRACT**

A smoke detector with a first cell sensing light scattered from matter to be detected and a second compensating cell has an adjustable plug for varying light from a source to the compensating cell and a diffuser for spreading the adjusted light over the same area of the compensating cell as the area of the first cell exposed to scattered light.

11 Claims, 5 Drawing Figures



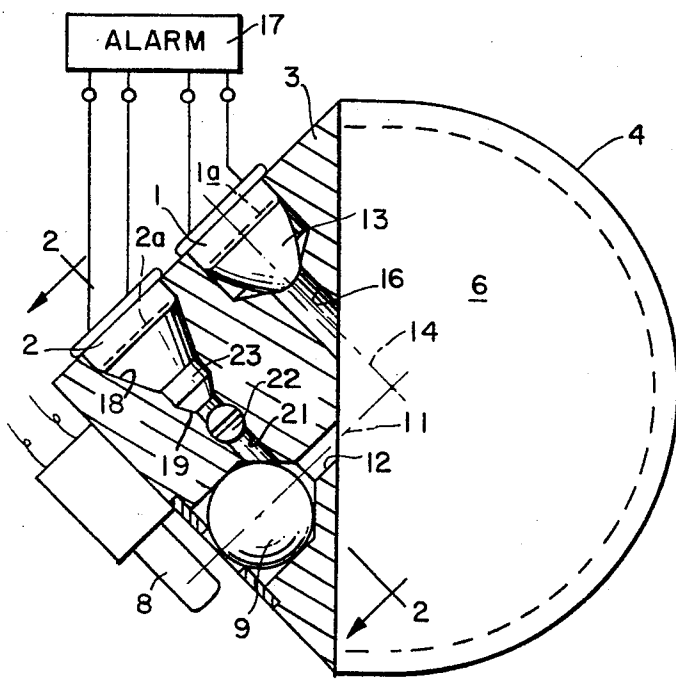


FIG. 1

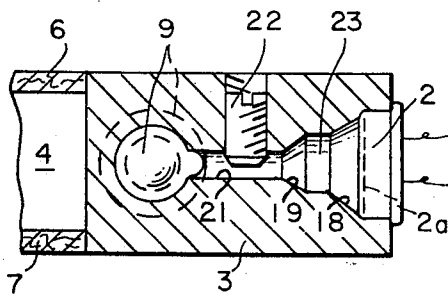


FIG. 2

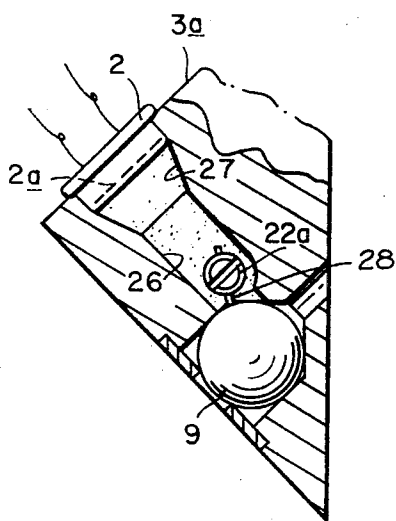


FIG. 3

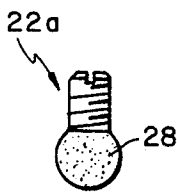


FIG. 4

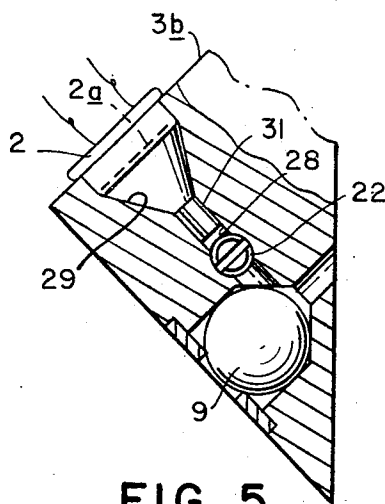


FIG. 5

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PHOTOELECTRIC DETECTOR WITH COMPENSATING PHOTOCELL

Scatter type smoke detectors include an exciter lamp illuminating a space in which particulate matter such as smoke is to be detected, and a sensing photocell viewing the space which is nearly dark, but at very low illumination constantly sensed by the cell. When particulate matter enters the space, light is scattered to the cell and the cell's light response increases triggering a threshold circuit for operating an alarm. The cell's response to light scattered from a given amount of matter may vary with age, temperature, applied voltage and change of lamp illumination among other factors. The change of cell response required to trigger the threshold circuit is thereby varied, reducing the reliability of the detector or causing false alarms. The above factors can be temporarily compensated by connecting a substantially identical compensating cell in the threshold circuit and exposing it to light from the exciter lamp. Such an arrangement is shown in U.S. Pat. No. 2,476,958 to C. N. Cahusac et al together with a shutter for varying the area of the compensating cell's photosensitive surface exposed to light from the exciter lamp. A similar arrangement is shown in U.S. Pat. No. 3,409,885 to R. N. Hall which suggests that in addition to the adjustable shield or shutter, a filter over the cell can provide a further attenuation of light on the partly exposed photosensitive surface.

There are, however, factors causing differences in cell response in addition to those mentioned above, and which are not compensated by prior arrangements. It is known that photoconductive cell sensitivity will change as a function of age, and that the ageing rate will be affected by the light intensity, as measured in lumens per area. Heretofore, devices utilizing a balanced photocell circuit have obtained desired electrical balance (current flow) by changing the exposed area of the compensating cell as compared to the fixed illumination and area of the sensing cell. Such a procedure matches the current flow through the totally illuminated sensing cell, with parallel currents flowing through the differentially illuminated compensating cell. Where as much as 90 percent of the compensating cell is shielded from light, causing the electrical impedance of the shielded portion to be substantially higher than that of the sensing cell, the remaining small area of the compensating cell surface must receive a substantially higher intensity of light than that falling on the sensing cells in order to match the impedance of the totally illuminated sensing cell. Such an imbalance of light intensities leads to a variation of ageing rates with resulting disparity between the sensitivities of the two cells after a period of time.

As a second example, accepted curves of photoconductive cell temperature co-efficients show that conductance will change as a function of temperature and that the percent of change per degree temperature will vary in proportion to the light intensity at the photoconductive surface. Thus, in prior devices which exposed a part of the compensating cell surface to higher level of illumination than that on the surface of the sensing cell, the two cells operated at different co-efficients. At the very low light levels in smoke detectors (0.01 to 0.001 foot candles) the effect of temperature differences between cells is greatly magnified.

A third example of a factor causing differences in the responses of two cells is the pre-existing level of light intensity on respective cells. The percentage of change in cell conductance with a given change of incident light intensity will vary greatly depending on the initial light level at the photoconductive surface of the cell. Thus, where the compensating cell is partly illuminated at a higher light level than a larger area of the sensing cell, a change in emission from the exciter lamp, for example, may result in a cell imbalance which reduces the detector's sensitivity to smoke, or on the other hand causes a false alarm.

It is the object of the present invention to provide a dual cell detection device which further compensates for the above described factors causing disparities in response of the respective cells.

According to the invention apparatus for detecting matter in a space comprises a light source for illuminating the space, first and second photosensitive devices having substantially equal light sensitive areas, the first of said devices being exposed to light scattered from matter in the space and the second device being exposed to light from the source, and means to control the amount of light on the second device, wherein said control means includes means to spread the controlled amount of light over substantially the same light sensitive area of the second device as the first device exposed to light in said space.

For the purpose of illustration typical embodiments of the invention are shown in the accompanying drawing in which:

FIG. 1 is a sectional view of a dual cell smoke detector having a light controller;

FIG. 2 is a section on line 2—2 of FIG. 1;

FIG. 3 is a sectional view like FIG. 1 of a smoke detector having a modified form of light controller;

FIG. 4 is an elevation showing the light controller of FIG. 3 enlarged; and

FIG. 5 is a sectional view like FIG. 1 showing a further modification.

FIGS. 1 and 2 show a scatter type of smoke detector which comprises a semi-circular space enclosed by an opaque triangular block 3, and by a semi-circular wall 4 and upper and lower walls 6 and 7 of porous material which substantially exclude ambient light from the space, but rather freely admit air-borne particles into the space as fully described in U.S. Pat. No. 3,497,303.

Mounted outside the triangular block 3 is an exciter lamp 8 whose rays are directed by a ball lens 9 along a path 11 through a passage 12 into the enclosed space. A first photoconductive cell 1 recessed in the block 3 and having a disk-shaped photosensitive area 1a views the space through a bullet lens 13 along a path 14 through a passage 16 in the block 3. In the absence of smoke in the chamber substantially the whole photosensitive area 1a of the first photocell 1 receives a very low but finite level of light leaked through the porous walls 4, 6 and 7, or from exciter lamp illumination reflected from the interior surfaces of the walls through the passage 16. This residual light level affects the ageing and sensitivity of the cell to light changes. When smoke circulates into the viewed space a substantially higher level of light from the lamp 9 is scattered back through the passage 16 thereby increasing the conductance of the photocell 1, and, if the smoke is

sufficiently dense, triggering an alarm circuit 17 to which the cell is connected. As previously explained, the cell's sensitivity and conductance unavoidably changes with age and operating factors.

Partly to compensate for these factors a second photoconductive cell 2, selected for substantially identical response characteristics and photosensitive area 2a as for the first cell 1, is shielded from light in the illuminated space but receives some of the light from the exciter lamp 8.

The second photocell 2 is recessed in the block 3 and optically communicates with the ball lens 9 through tapering passages 18 and 19 and a straight passage 21 terminating at the ball lens. The passage 18 adjacent the photocell 3 flares wider than the photosensitive area 2a. Light transmission from the lens into the passage 21 is weak, and is further reduced by a screw plug 22 threaded into the block 3 and adjustable in and out of the passage 21, more or less to obstruct light transmitted through the passage onto the photosensitive surface 2a of the second photocell. Preferably the light is reduced to a level such that it reaches the second photocell 2 in an energy amount (lumens) equivalent to the amount on the first photocell 1 in normal, no smoke, condition.

In addition to the plug adjustment, light falling on the photosensitive area 2a is controlled by a frosted glass diffusing disk 23 located beyond the screw plug 22 and between the tapering passages 18 and 19. Whereas the screw plug 22 would transmit light preferentially to one side of the photosensitive area 2a, the diffuser disk 23 spreads light fairly anisotropically throughout the tapered passage 18 and substantially uniformly over the photosensitive area, and insures that in addition to receiving the same amount of light (lumens) the two photosensitive areas 1a and 2a receive light at the same level of intensity (foot candles) and color temperature over the same areas. The above additionally provided conditions will allow the two cells to age at the same rate with respect to area, light intensity and temperature.

FIGS. 3 and 4 show an alternate way of controlling the amount and spreading of light on the photosensitive area 2a. Light from the ball lens 9 in a triangular block 3a is transmitted to the photosensitive area 2a through a straight passage 26 and a tapered passage 27 flaring wider than the photosensitive area 2a. A modified screw plug 22a carries a circular vane 28 disposed in the straight passage 26. Angular adjustment of the plug and vane adjust the amount of light transmitted to the photocell 2. The circular vane 28 has a high reflectance, diffuse reflecting surface such as provided by flat white optical paint. The walls of the passages 26 and 27 are also coated with diffuse reflecting paint. With such a diffuse surface on the vane and passage walls, or either of them, a controlled amount of light is spread very uniformly over the photosensitive surface 2a as in the case of FIGS. 1 and 2.

In FIG. 5 the triangular block 3b has a flared passage 29 and straight passage 28 between the ball lens 9 and photocell 2. A plug 22 like that shown in FIGS. 1 and 2

controls light transmitted through the passages. In the straight passage 28 adjacent the flared passage 29 is a translucent cylinder of an internally diffusing solid such as milky glass and like plastic materials such as Nylon and Teflon.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents falling within the scope of the appended claims.

I claim:

1. Apparatus for detecting particulate matter in a confined space comprising: a light source for illuminating the space, first and second solid state photosensitive devices having substantially equal light sensitive areas, the first of said devices being exposed over its total area to light scattered from matter in the space and the second device being exposed to light from the source, said devices being connected to an alarm circuit so that the second device compensates for variations in sensitivity of the first device, and means to control the amount of light on the second device, wherein said control means includes means to spread the controlled amount of light over substantially the same light sensitive area of the second device as the area of the first device exposed to light in said space, thereby to light age the two photosensitive devices substantially equally.

2. Apparatus according to claim 1 wherein said control means comprises means for adjusting light from said source, and said spreading means is between the adjusting means and the second light sensitive area.

3. Apparatus according to claim 1 wherein said control means comprises means for diffusing controlled light over substantially the entire light sensitive area of said second device.

4. Apparatus according to claim 1 wherein said spreading means comprises a light diffuser.

5. Apparatus according to claim 2 wherein said spreading means comprises a light diffuser.

6. Apparatus according to claim 1 wherein said spreading means comprises diffuse light transmitting means.

7. Apparatus according to claim 1 wherein said spreading means comprises diffuse light reflecting means.

8. Apparatus according to claim 1 wherein said spreading means comprises an internally light diffusing solid.

9. Apparatus according to claim 1 characterized by wall means forming a light passage between the light source and second device, adjustable means variably obstructing said passage, and diffusing means in said passage between the adjustable means and device.

10. Apparatus according to claim 9 wherein said spreading means comprises a diffuse reflecting surface on said wall means.

11. Apparatus according to claim 1 wherein said control means is adjustable through the range of light intensities normally falling on the first photosensitive device.

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