Aug. 12, 1969 A. W. VASEL 3,461,443

SMOKE DETECTOR WITH MEANS INDICATING THE FAILURE OF THE LIGHT SOURCE

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Fig. 1

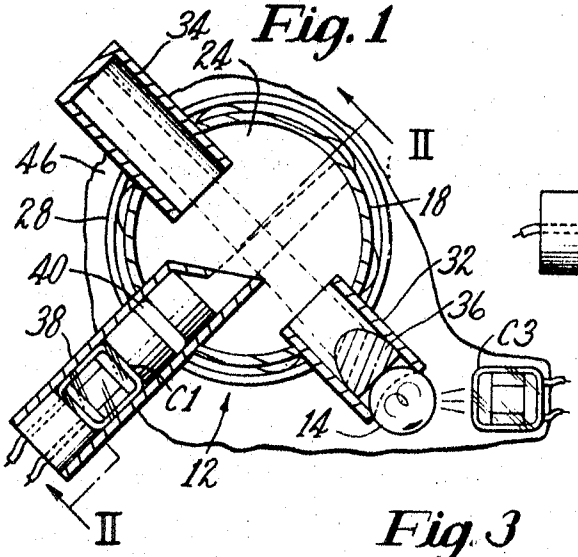


Fig. 2

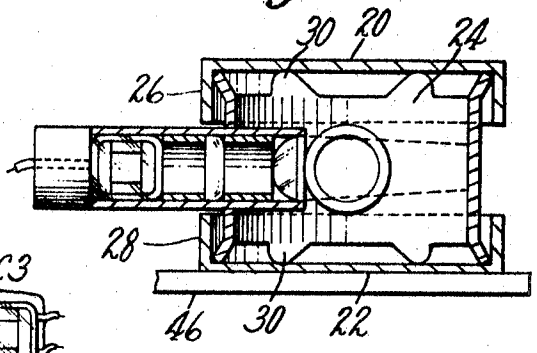
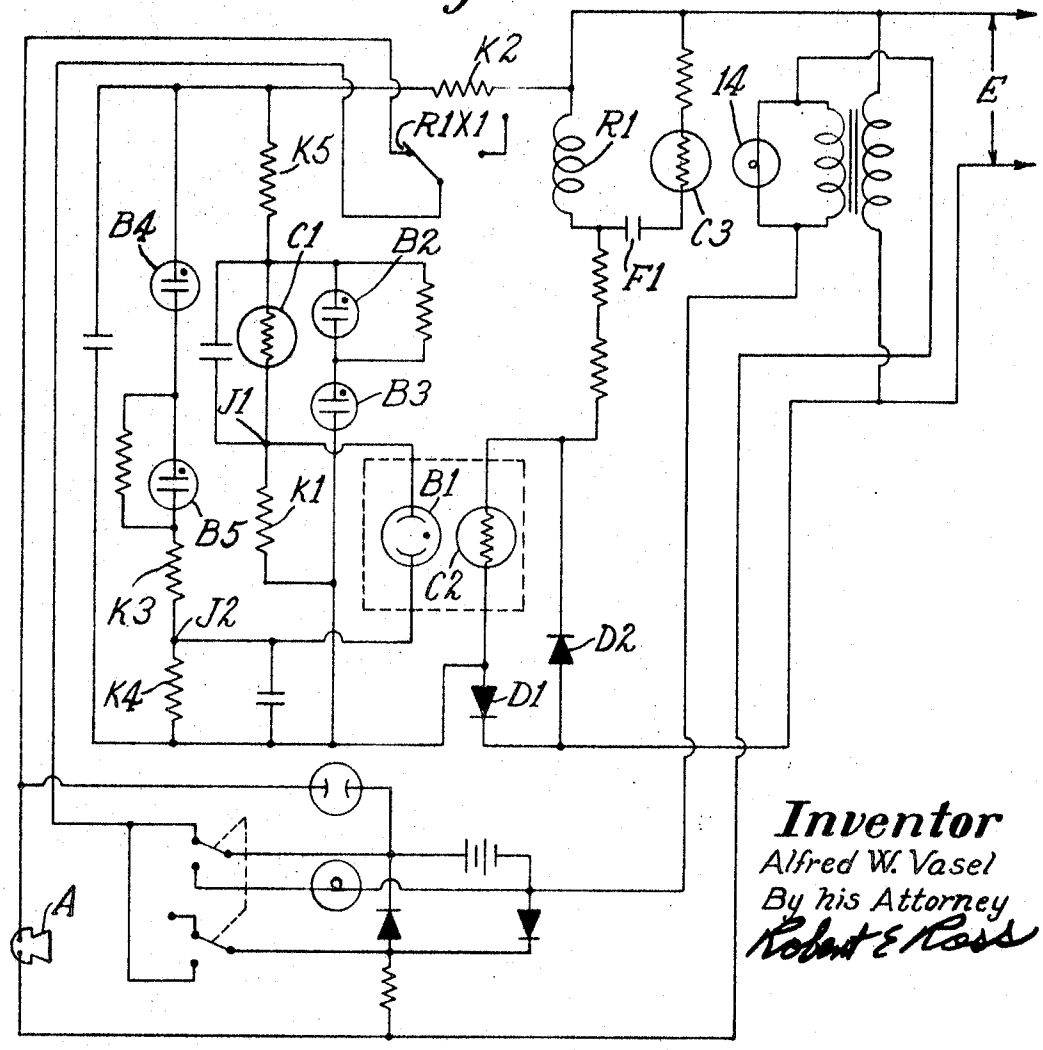


Fig. 3



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SMOKE DETECTOR WITH MEANS INDICATING THE FAILURE OF THE LIGHT SOURCE

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ABSTRACT OF THE DISCLOSURE

A smoke detector in which the failure of the light source causes an audible signal by means other than the smoke alarm.

This invention relates generally to particle detectors and has particular reference to a smoke detector of the diffusion type and to an improved alarm circuit for use therewith.

Particle detectors of this type utilize a darkened chamber through which gas or liquid is forced or allowed to diffuse, with means projecting a light beam across the chamber. A photocell is provided which views the medial portion of the light beam and is shielded from the direct radiation from the light source. When particles carried by the fluid medium appear in the light beam, the light is reflected therefrom onto the photocell. The resulting decrease in resistance of the cell is utilized to actuate an external alarm system.

Devices of this type are finding wide use in both industrial and residential applications, however they have been found to have a number of disadvantages in certain applications.

Since the amount of illumination reaching the photocell under a predetermined smoke concentration is a function of the brightness of the like beam, which is dependent on the voltage applied to the light source, it will be apparent that the smoke concentration at which the alarm will be sounded will vary with the line voltage applied to the light source. In other words, when the line voltage is below normal so that the light source is less bright than normal a greater smoke concentration will be required to actuate the alarm than when the voltage is higher than normal and the light source is brighter than normal. This effect is amplified by the fact that the line voltage variations also affect the voltage applied across the photocell.

Another difficulty with such devices has been the problem of providing economical means for indicating a failure of the light source. Although a system in which the failure of the light source would actuate the alarm is simple to design and build, it has been considered undesirable to have the smoke alarm utilized for this purpose, and the provision of a separate alarm to indicate bulb failure is too expensive for many applications.

Hence an object of this invention is to provide a smoke detector in which means is provided for greatly diminishing the effect of line voltage variations on the smoke concentration at which the alarm is actuated.

A further object of this invention is to provide a smoke detector in which the failure of the light source causes an audible signal by means other than the alarm provided to indicate the presence of smoke.

Other objects of the invention will be apparent to one skilled in the art from the following detailed description of a specific embodiment thereof.

In the drawing:

FIG. 1 is a top plan view of a particle detector labyrinth for use with a smoke detector embodying the features of the invention, partly broken away to show the interior arrangement;

FIG. 2 is a view in section taken on line 2—2 of FIG. 1; and

FIG. 3 is a schematic diagram of the electrical circuit of a particle detector embodying the features of the invention.

Referring to the drawing there is illustrated a particle detector which includes generally a housing **12**, a light source **14** disposed outside the housing, and a detector element C1 disposed in the housing in operative relation to appear hereinafter.

The detector **10**, in the illustrated embodiment, is particularly adapted for use as the detector unit of a smoke alarm and for this purpose the housing **12** comprises a peripheral wall **18** having a pair of end caps **20** and **22** forming an internal dark chamber **24**. The end caps extend beyond the periphery of the wall **18** and have inwardly turned flanges **26** and **28** which are spaced outwardly from the wall. Each end of the wall is provided with a series of outwardly inclined spacing lugs **30**, which are adapted to engage frictionally the inner surface of the flanges to retain the caps in assembly. The flanges **26** and **28**, in conjunction with the spacing lugs **30**, form a peripheral passageway at each end of the wall to permit smoke to enter the chamber from the surrounding atmosphere.

To direct and control the beam from the light source **14**, a focusing tube **32** extends through the housing wall on one side thereof, and a light trap tube **34** is disposed in the housing wall on the opposite side in alignment with the focusing tube **32**. A lens **36** of the converging type is disposed in the focusing tube **32**, with a focal length such that light from the source **14** is focused in a converging beam onto the bottom of the light trap tube **34**, so that the beam from the light has a minimum size at the bottom of said trap, and a minimum amount of the light from the source falls on any other portion of the interior surface of the housing.

A detector tube **38** extends through the housing wall between the light trap tube and the focusing tube, and is disposed generally perpendicular to the axes thereof. The detector element C1 is disposed in the detector tube, and to restrict the field of view of the detector, a lens **40** of the converging type is disposed in the detector tube between the detector element and the chamber. The lens **40** has a focal length such that the image of the detector element is focused onto a minimum area on the opposite surface of the housing wall and the cone of focus of the detector element is directed across the cone of focus of the light beam, so that the detector element views only the medial portion of the light beam and the field of view of the cell at the opposite wall portion is confined to the medial portion of the wall, so that the cell does not view the peripheral apertures at the top and bottom of the wall. Hence substantially no light reaches the detector element except light appearing in the focus cone of the lens **40**. To further insure that a minimum amount of the internal stray light reaches the detector element, the end **42** of the detector tube on the side adjacent the light tube extends forwardly to the cone of focus of the light beam to provide a shield against stray light from the inside surface of the focus tube. The end of the detector tube from this foremost point is inclined rearwardly at an angle such that the inside surface of the detector tube cannot view the inside surface of the focus tube. To prevent stray reflected light from the inside of the light trap tube from reaching the detector lens **40**, the side of the end of the detector tube adjacent the light trap tube is provided with an inclined shield **44**.

In the illustrated embodiment the housing **12** is adapted to be mounted onto a support panel **46**, and the light source **14** is also mounted on the panel in alignment with

the focusing tube 32, and connected to a suitable source of electric current. The external mounting of the light source provides a visual check on its condition and makes replacement convenient.

The detector element C1 may be any type of device which is responsive by a change in resistance to a change in light intensity, such as a photo-resistive cell. One type of cell which has been found satisfactory is cadmium sulfide, which responds to an increase in light intensity by a decrease in resistance. Hence in the illustrated embodiment a detector circuit may be connected to the detector element and adjusted to the cell resistance under normal conditions of no smoke so that a predetermined further decrease in cell resistance will actuate an external alarm connected to the detector circuit. When smoke enters the housing and appears in the light beam, light from the smoke particles in the portion of the light beam viewed by the detector is reflected or diffused onto the detector cell, thereby lowering the resistance of the cell and actuating the alarm circuit. The physical structure and operation of the above described housing is the subject matter of a co-pending application Ser. No. 396,629, filed Sept. 15, 1964 by the present inventor and Rudolph W. Kalns.

Referring to FIG. 3, there is illustrated an alarm and control circuit for use with the labyrinth of FIGS. 1 and 2. The circuit of FIG. 3, which is energized from an alternating current source E, is intended to de-energize a normally energized DC relay R1, to close contacts R1X1 to energize an alarm A when the cell C1 views illuminated particles in the light beam in the labyrinth, in a manner to be described.

The relay R1 is connected across the source of voltage E in series with a pair of parallel circuit paths, one of which includes a photocell C2 and a diode D1, the other of which includes a diode D2 poled in a direction opposite to that of the diode D1. In parallel with the relay R1 is a photocell C3 and a capacitor F1.

The photocell C3 is positioned to receive light from the light source 14 whenever said light source is energized, and the photocell C2 receives light from an adjacent neon bulb B1 which is energized only when photocell C1 is illuminated by smoke particles, in a manner to appear hereinafter.

Therefore, during normal operation of the device, under conditions of no smoke, the circuit path which includes the normally dark photocell C2 is a high resistance path, so that only half wave voltage is applied to the relay R1, and to the capacitor F1 and cell C3 in parallel therewith. The cell C3 is normall conductive, since it is illuminated by the light source 14. The half wave voltage is therefore capable of maintaining the relay R1 energized since the capacitor F1 in parallel therewith stores sufficient energy on the half cycle in which the diode D2 is conductive to maintain the relay R1 pulled in by discharging on the opposite half cycle during which the diode D2 is not conductive.

When cell C1 is illuminated by smoke particles in the manner previously described, the neon bulb B1 is energized (in a manner to appear hereinafter) thereby illuminating cell C2 and rendering it conductive, so that full wave voltage is applied across the relay R1 and the capacitor F1. Since the capacitor F1 is a low impedance shunt to full wave AC voltage, and the relay is a DC operated device the voltage across the relay R1 drops to a value such that the relay is deenergized allowing contacts R1X1 to close and energize the alarm.

As previously mentioned, it is considered desirable to provide some means other than the main smoke alarm to indicate the failure of the smoke illuminating light source. The above described portion of the circuit accomplishes this in the following manner. If the light source 14 should fail (under normal no-smoke operating conditions), the resistance of photocell C3 increases to a substantially non-conductive condition. The capacitor F1 thereby becomes ineffective to supply current to the relay R1 on the portion of the cycle during which diode D2 is non-conductive so that only half wave voltage is applied to the relay. Although the relay remains energized, so that contacts R1X1 remains open; the intermittent unidirectional voltage applied to the relay causes the armature to vibrate or "chatter" with an audible sound loud enough to attract the attention of any person in the vicinity of the device.

The neon bulb B1 is energized to actuate the alarm, in the manner previously described, when the cell C1 "sees" illuminated smoke particles, in a manner now to be described. The cell C1 is connected across the voltage source in series with a resistor K1, and the diode D1, and the neon bulb B1 is connected to the junction J1 between the cell C1 and the resistor K1. Since the cell C1 is normally not illuminated and therefore has a high resistance, the voltage at the junction J1 is below the striking voltage of the neon bulb B1. When smoke particles enter the chamber and are viewed by the cell C1 its resistance drops, and when the predetermined concentration of smoke is present in the housing, the resistance of the cell C1 drops to a value low enough to allow the voltage at J1 to reach the igniting voltage of the neon bulb B1, thereby actuating the alarm in the manner previously described.

As previously described, the concentration of smoke at which the alarm will be actuated will be influenced by the supply voltage. An increase in supply voltage, unless some compensating effect is provided, will cause the alarm to be actuated at a lower smoke concentration than is desired for two reasons. First, the greater voltage will cause an increased brightness of the light source 14 so that more light is reflected from the smoke particles onto the cell C1, and second, a higher voltage is applied to the cell C1 so that the ignition voltage of the neon glow tube B1 is reached at a higher resistance of cell C1. A supply voltage lower than normal would result in the opposite effect that is, decreased brightness of the light source 14, and less voltage applied to the cell C1, so that the alarm would be actuated only when the amount of smoke in the housing is greater than the predetermined amount.

To prevent line voltage variations from appreciably affecting the voltage applied to the cell C1, a pair of neon glow tubes B2 and B3 are connected in parallel with the cell across the voltage source, and both the glow tubes and the cell are connected to the voltage source through a resistor K5 so that the voltage at the cell C1 is maintained relatively constant by the regulating effect of the glow tubes.

As previously described, the variations in supply voltage cause variations in brightness of the light source 14 which will cause a variation in the amount of light received by the cell C1. With a predetermined amount of smoke present in the housing, therefore, the voltage at the junction J1 will vary as a function of the supply voltage. Hence the amount of smoke necessary to be present in the housing to cause the voltage at point J1 to reach the ignition temperature of the glow tube would vary with the supply voltage. To compensate for this obviously undesirable effect, means is provided for varying with variations in the supply voltage the voltage required at J1 to ignite the glow tube, by applying a bias voltage to the opposite side of the glow tube in the following manner.

In the illustrated embodiment the bias for the glow tube is obtained from junction J2 of two series resistors K3 and K4 connected through two voltage regulating glow tubes B4 and B5 to the supply voltage.

The addition of the bias voltage obtained at J2 to the side of the glow tube B1 opposite junction J1 changes the voltage required at junction J1 to ignite the glow tube B1 in a manner now to be described. When the supply voltage E rises above normal, causing the light source 14 to increase in brightness, and, if smoke is present in the housing, raising the voltage at J1, the increased voltage through the regulating tubes B4 and B5 and through the resistors K3 and K4 increases the voltage at junction J2 and consequently at the adjacent side of the glow tube B1. There-

fore a greater voltage is required at the junction J1 to ignite the glow tube, thereby compensating for the increased brightness of the light source 14. Conversely a lower supply voltage E will decrease the bias voltage at junction J2, and under such condition less voltage will be required at junction J1 to ignite the glow tube B1 at the predetermined smoke level, thereby compensating for the fact that the lower supply voltage has reduced the brightness of the light source 14.

By a selection of appropriate values of the various components of the circuit, the change in bias voltage at junction J2 can substantially eliminate the effect of variations in brightness of the light source 14 so that the glow tube B1 is ignited and the alarm sounded at substantially the same smoke concentration regardless of whether the supply voltage E is above or below normal. In a typical embodiment, it may be assumed that the normal supply voltage E is 120, and bias voltage at junction J2 is 12 volts and the voltage between terminals necessary to ignite the glow tube is 60 volts. 72 volts is therefore required at junction J1 to ignite the glow tube. An increase in supply voltage to 132 volts will result in an increase in brightness of the light source. When the predetermined smoke concentration is present in the housing, the greater reflection from the smoke particles may cause the voltage at J1 to be, for example, 76 volts. To prevent the alarm from being energized prematurely, it is therefore necessary that the bias voltage at junction J2 increase to 16 volts.

If the supply voltage drops to 110 volts, for example, the voltage at junction J1 (resulting from decreased brightness of the light source) may be only 68 volts when the predetermined amount of smoke is present in the housing. The bias voltage must therefore drop to 8 volts. It will be apparent that the required voltage bias to be applied to the glow tube B1 will be influenced by the characteristics of the light source 14 and the photocell C1, and the other components of the circuit must be selected in accordance with said characteristics.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. An alarm control circuit, including a relay having a normally energized coil, alarm energizing contacts which are actuated to energize said alarm on deenergization of said coil, means for energizing said coil with one half wave of an alternating current supply, capacitor means associated with said coil for supplying current to said coil on the other half of the alternating current supply, and means responsive to the failure of a predetermined component of said alarm control circuit to render said capacitor ineffective to supply current to said coil on said other half of the alternating current supply without interrupting the half wave current supply to said coil, whereby only half wave current is applied to said coil causing the contacts of said relay to emit an audible signal.

2. An alarm control circuit, including a relay having a coil, and contacts for completing a circuit to an alarm device when the coil is deenergized, a half wave rectifier in series with said coil, a capacitor in parallel with the coil to provide current to the relay during the portion of an energizing alternating current cycle when current is not being supplied by the rectifier and means responsive to the failure of a predetermined component of said alarm control circuit to render only said capacitor ineffective to supply current to said coil, whereby only half wave current is applied to said coil to cause the contacts of said relay to chatter providing an audible alarm signal different from that emitted by the alarm device.

3. An alarm control circuit for a smoke alarm which utilizes a light source for detecting smoke particles, comprising a relay having a coil and at least a pair of contacts adapted to be held in one condition when the coil is energized by full wave alternating current and in another condition when the coil is de-energized, said contacts being subject to chattering when the coil is energized by half wave current, a half wave rectifier in series with the coil, a photo-resistive cell and a capacitor in series with each other and in parallel with the relay coil, said cell being positioned to receive radiation from said light source so that it is normally conductive whereby when said circuit is energized from an alternating current source, said capacitor provides current to said relay during the period when current is not being provided by the rectifier so long as said light source is operative but on failure of said light source, only half wave current from the rectifier is applied to said coil to cause the relay contacts to chatter to indicate failure of the light source.

4. A control circuit for use with an alternating current supply, comprising a controlled device having one condition when full wave alternating current is applied thereto, a second condition when half wave current is applied thereto, and a third condition when no current is applied thereto, a pair of current paths to said device, one path constantly providing half wave current to said device, the other path providing half wave current to said device under predetermined conditions, both paths together providing full wave current to said device under said predetermined conditions, and a capacitor and circuit interrupting means in series with each other and in parallel with said device, whereby half wave current from said first path alone in cooperation with said capacitor provides in effect full wave current to said device when said circuit interrupting means is conducting, and half wave current to said device when said circuit interrupting device is not conducting, said capacitor effectively shunting said device so that no current is applied thereto during said predetermined conditions.

No references cited.

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U.S. Cl. X.R.

250—206; 315—134; 317—124, 151; 340—237