

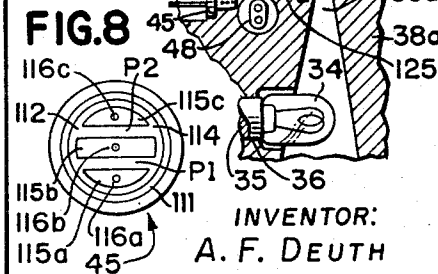
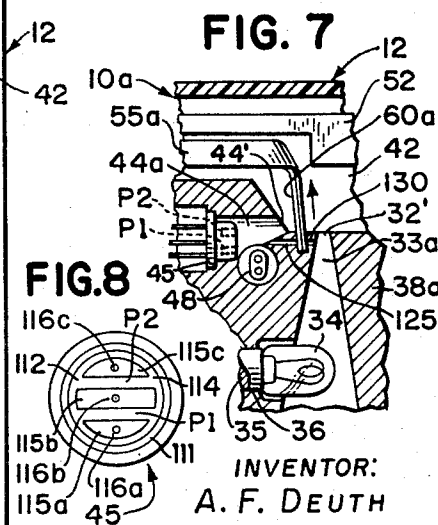
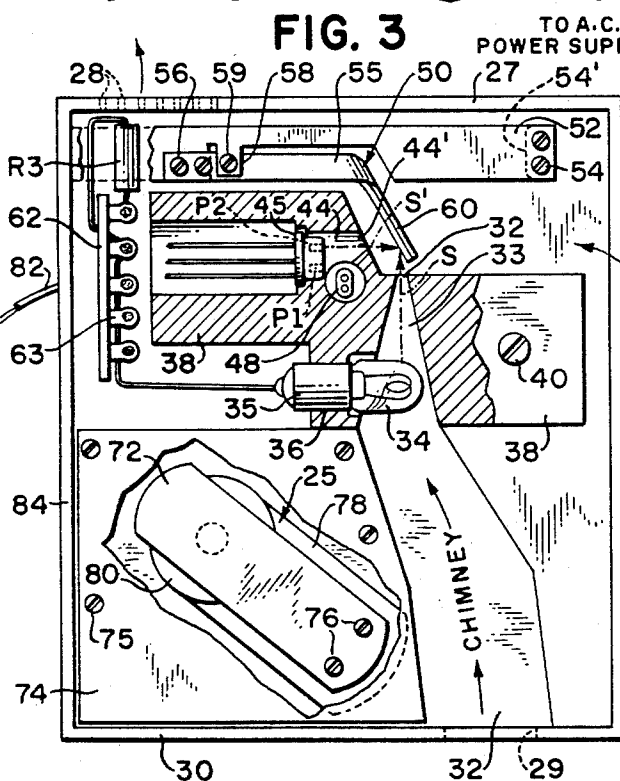
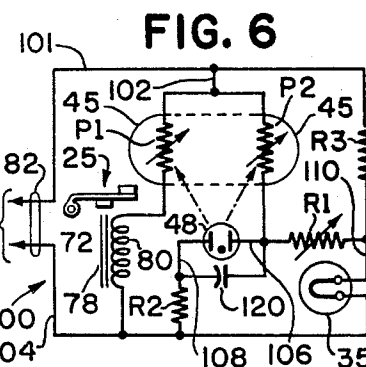
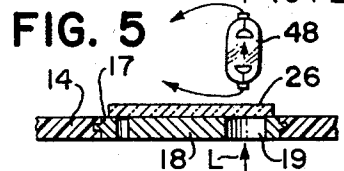
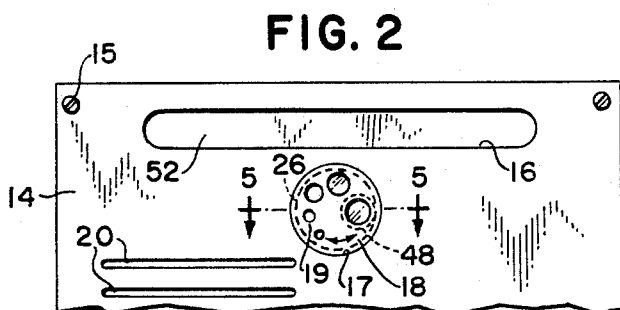
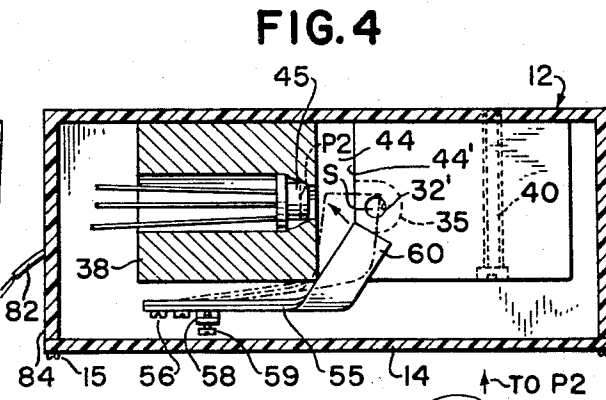
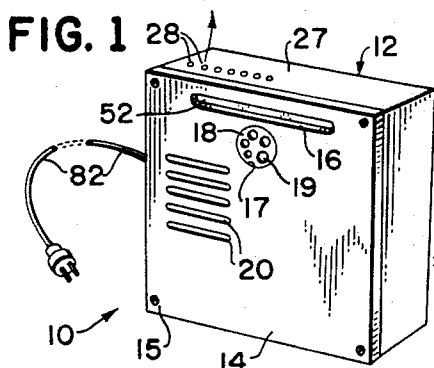
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3,430,220

FIRE DETECTOR

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3,430,220

FIRE DETECTOR

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ABSTRACT OF THE DISCLOSURE

A fire detector senses abnormal conditions of smoke, flame and heat. Each condition causes light from an internal lamp or external flame to fall on a photoconductive element which activates a gas discharge tube. The tube lights and illuminates another photoconductive element connected in direct circuit with an alarm device without intermediate relay means. The lamp is arranged in circuit with the tube so that the tube lights and the alarm device is activated, if the lamp fails. Response of the detector to the conditions of smoke, flame and heat is cumulative so that the alarm will be actuated if any two or three conditions are sufficiently intense, even though any one condition is not intense enough to actuate the alarm.

This invention relates to the art of fire detectors and more particularly concerns a fire detecting device which simultaneously senses and responds to predetermined abnormal conditions of smoke, flame and heat.

Heretofore fire detectors have been known which will respond to one or at most two of the conditions generated by a fire. The present invention is directed at a device of surprisingly small size and relative simplicity which will respond to all three conditions produced by a fire; and will respond in a way whereby its total response is the summation of its responses to each of the three conditions. This cumulative or additive response is an important feature of the invention. A further desirable and advantageous feature of the invention is the provision of means for adjusting the device to respond to the three conditions individually to different predetermined limits.

It is therefore a principal object of the invention to provide a fire detector device having three senses or response capabilities, to detect abnormal conditions of smoke, flame and heat generated by a fire.

Another object is to provide a fire detector as described, wherein means are provided so that each of the response capabilities or senses are individually but cooperatively adjustable.

A further object is to provide a fire detector device responsive to smoke, flame and heat conditions, and arranged so that if the device responds partially to the occurrence of any one of the three conditions, its sensitivity to occurrence of the other two conditions will be automatically increased.

Another object is to provide a fire detector device responsive to smoke, flame and heat conditions, whereby the total response of the device to the three conditions is the summation of its individual responses to the three conditions respectively.

Other objects of the invention are to provide a fire detector device which employs a self-triggering light amplifier including photoconductive elements and a simple, inexpensive gas tube; which maintains its critical internal components in an unloaded condition so that these components will remain in order and operative at all times; which is small in size and weight and contains such few, inexpensive components that it can be manufactured and sold at a much lower price than conventional fire detectors of less versatility and detecting capability; which

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consumes very low power, in general, no more than a few watts; which can be easily arranged for remote alarm installation and actuation; which is easy to install and easy to test for operativeness and effectiveness; which employs a continuously lighted lamp in a fail-safe arrangement to sound an alarm if the lamp burns out; which avoids the use of electromagnetic relays and relay contacts; which is faster and more reliable in response and operation than conventional fire detectors; and which has other advantageous features.

Other objects and advantages of the invention will become apparent from the following detailed description, taken together with the drawing, wherein:

FIG. 1 is a reduced perspective view of a fire detector device embodying the invention.

FIG. 2 is an enlarged front view of part of the device.

FIG. 3 is an enlarged front view of the device with its cover removed and certain internal parts broken away to show internal construction.

FIG. 4 is a simplified cross sectional view, with parts omitted to illustrate the mode of operation of the device.

FIG. 5 is a further enlarged fragmentary sectional view taken on line 5—5 of FIG. 2.

FIG. 6 is a diagram of the electrical circuit of the device.

FIG. 7 is a fragmentary view similar to a portion of FIG. 3, and illustrating a modification of the invention.

FIG. 8 is a front view on an enlarged scale of a dual element photoconductive cell which may be employed in the device.

Referring first to FIGS. 1-5, there is shown the fire detector device 10, including a rectangular base 12 with open front closed by a removable rectangular front cover 14 to define a rectangular casing for the device. Corner screws 15 are used to attach the cover to the base. In the front cover 14 near the upper edge thereof is an elongated horizontal slot 16 intended to admit air heated by a fire as well as heat radiated by a fire in the vicinity of the device. Just below slot 16 in opening 17 is a rotatable apertured disc or plate 18. This plate has circumferentially spaced openings 19 of graduated sizes. The plate 18 can be rotated so that any one opening is located at a flame sensing position L to admit the light of a flame in the vicinity of the device. A plurality of slots 20 located below and laterally of plate 18 is provided to pass the sound of an alarm buzzer 25 disposed in base 12. Behind plate 18 is a transparent red filter 26 which passes predominantly infra-red light into the casing; see FIG. 5. The filter can be stationary or rotatable with plate 18.

In the upper wall 27 of the base 12 is a plurality of holes 28 which permit smoke to pass out of the casing. The smoke may enter through a hole 29 in the bottom 30 of the casing and can pass upwardly through a tapered passage or chimney 32. At the upper end of the chimney 32 is a tapered chamber terminating in an opening or orifice 32'. The bulb 34 of a lamp 35 held in aperture 36 of a massive block 38 extends into chamber 33. Block 38 is secured by a bolt 40 to the back of the base 12.

Orifice 32' opens into a smoke collection chamber 42. Holes 28 open into chamber 42 and through these holes smoke in chamber 42 is exhausted from the casing. A small, tapered, light reception chamber 44 is formed in block 38 laterally of the chimney orifice or opening 32'. At the left end of this chamber as viewed in FIGS. 3 and 4 is a photoelectric cell of the photoconductive type. This cell is provided with two photoconductive elements or sensors which are independently responsive to light impinging on them so that they change in internal electrical resistance or conductance when the incident light changes. These sensors P1 and P2 are normally maintained in substantial darkness since they are out of the line of sight S from lamp bulb 34 passing through chimney open-

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ing 32'. Adjacent to the cell 45 is a gas discharge tube 48, preferably a two-element neon tube. This neon tube is disposed so that its transparent glass bulb is axially aligned with the light admitting position L of plate 18 as clearly shown in FIG. 5. Light can pass through this tube from outside the device directly into chamber 44. Normally this light level will be so low under ordinary ambient lighting conditions that it has substantially no effect on the photoconductive sensors P1 and P2.

In chamber 42 is a heat sensitive assembly 50 including a massive thermal pickup plate 52 mounted by screws 54 at its ends on projections 54' in base 12. The plate 52 is exposed to heated air entering slot 16. It is also exposed to radiant heat rays from a fire entering through slot 16. The plate 52 supports a thin bimetallic strip 55 attached at one end by screws 56 to plate 52. The strip 55 is heated by conduction of heat from plate 52. Plate 52 has a lateral extension 58 carrying a screw 59 which is used to bear on the bimetallic strip for adjusting its position in a fore and aft direction with respect to the line of sight S. The right end of the strip has a turned down flag or vane 60. The vane is turned rearwardly and angularly to the line of sight S. The vane is normally located forwardly of this line of sight as clearly shown in FIG. 4, so that the vane 60 does not normally reflect any light into chamber 44.

A terminal strip 62 is mounted in the base 12. This strip has lugs 63 to which various electrical components of the device are connected, including resistor R3 disposed near holes 28. All electrical components are connected in a circuit explained below in connection with FIG. 6.

Included in the device is buzzer 25 having a vibratory armature plate 72 which strikes against a sounding board 74 shown partially broken away in FIG. 3. The board 74 is mounted by screws 75 in the base. Armature plate 72 is made of springy metal and is secured by screws 76 at one end thereof to the core 78 of the buzzer. The buzzer has a coil 80 which magnetizes core 78 to attract armature plate for sounding an alarm continuously after the device is actuated by responding to one or more of the three conditions which it senses. The device is provided with a power supply cable 82 which passes through a hole in left wall 84 of the base 12.

In circuit 100 shown in FIG. 6 to which reference is now made, the power supply cable 82 has one wire 101 connected to the common junction or lead wire 102 of both photoconductive sensors P1 and P2 included in the common casing of the cell 45. The other power supply wire 104 is connected to one end or terminal of each of coil 80, resistor R2 and lamp 35. The other end of sensor P2 is connected to one terminal 106 of neon tube 48. The other terminal 108 of the neon tube is connected via resistor R2 to power supply wire 104.

Resistor R1 which is preferably a variable resistor or rheostat is connected between terminal 106 of the neon tube and the common junction of resistor R3 and terminal 110 of lamp 35. Resistor R3 is disposed in series with lamp 35 and is connected to power supply wire 101. Buzzer 25, in addition to coil 80 includes core 78 which magnetically attracts armature plate 72 for sounding the buzzer.

It will be appreciated that the most essential and vital component of the device is the dual element photoconductive cell 45. FIG. 8 shows one possible arrangement of cell 45 in front view. The cell has a generally cylindrical case 111 with an open front in which is a transparent lens 112. Behind the lens is a substrate on which is a layer 114 of photoconductive material such as activated cadmium selenide or sulphide. Three electrodes 115a, 115b, 115c are spaced apart diametrically of the layer 114. The exposed portion of layer 114 between spaced electrodes 115a, 115b defines photoconductive element P1. The exposed portion of layer 114 between spaced electrodes 115b, 115c defines the other photoconductive element P2. Lead wires 116a, 116b and 116c are con-

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nected to the electrodes 115a-115c respectively and extend outside the cell 45 for connection in circuit 100. If desired two separate photoconductive cells, each with one photoconductive element between two electrodes may be provided in chamber 44 in place of the dual element cell 45, but in general it will be more economical and convenient to use a dual element cell.

Element or sensor P2 of cell 45 is the primary detecting element for all three sensory responses and conditions. Element or sensor P1 passes current which energizes and actuates the buzzer 70 or other alarm, local or remote, when the circuit is triggered. The triggering signal for all three sensory conditions is a light signal which impinges upon element P2. The operation of the device 10 for all three senses and three conditions produced by a fire will be described separately.

Smoke sense

Referring to FIG. 3, it will be apparent that smoke enters the device from the bottom thereof through opening 29 and ascends the chimney 32. The smoke is concentrated at the constricted opening or orifice 32' of the chimney. The smoke subsequently leaves the device through vents or openings 28 after passing through chamber 42. A small draft is created by virtue of the heat from lamp 35 which is continuously lighted, and the heat from power resistor R3. This resistor is located near the vents 28 as clearly shown in FIG. 3. The smoke is concentrated at both opening 32' of the chimney and opening 44' of chamber 44 where the cell 45 is located. Reflected light from the smoke is viewed by element P2 through opening 44'. Element P1 should be located away from the line of sight S' between element P1 and the orifice or opening 44' so that it is not illuminated by light reflected by smoke into chamber 44.

When the smoke has concentrated to such a density that sufficient light from lamp 35 is reflected on to element P2 via the bent optical path S, S', the electrical resistance of element P2 will decrease to a value where the voltage across the neon tube 48 will fire or trigger this tube; see FIG. 6. The supply voltage (117 volts, A.C., 60 c.p.s.) applied at input 82 is divided between element P2 and principally resistor R1 and lamp 35. Capacitor 120 is connected across the neon tube and is in series with resistor R2. This has little effect on the division of voltage since the reactance of capacitor 120 at the low frequency (60 cycles per second) of the power supply is considerably larger than the resistance of resistor R1. Thus resistor R1 which is adjustable principally fixes the value of voltage across the neon tube 48 with respect to the signal resistance of element P2; and the value of resistor R1 can be selected or adjusted for the proper circuit sensitivity.

It will be noted that photoconductive element P1 is connected in a first direct series circuit with coil 80 of buzzer 25. Photoconductive element P2 is connected in a second series circuit with the same power supply, tube 48 and resistor R2. The lamp 35 is connected in a third series circuit with the power supply and resistor R3. Variable resistor R1 is connected between the second and third circuits to bypass lamp 35 and to apply voltage to tube 48 to light it in the event the resistance presented by lamp 35 becomes infinitely large due to burnout of the lamp.

The neon tube is physically positioned at chamber 44 with respect to the photoconductors such that some of its light falls on element P2 and some of it falls on element P1. When the neon tube fires, the light from this tube falling on element P2 further reduces the resistance of element P2 to a point where the current builds up through the neon tube to an equilibrium condition and the circuit is "locked-in" or "latched" and will continue to operate even with the removal of the smoke or other sense signal.

The condition of equilibrium is primarily determined by the value of resistor R2 which limits the current

through the neon tube to a safe value. Thus the optical feedback provides, in effect, a light amplifier wherein the small triggering current is amplified many times by virtue of the feedback. Most of the light from the "locked-in" neon tube falls on element P1 and reduces its resistance to a very low value so that nearly all of the supplied alternating voltage is "switched" across coil 80 of the buzzer which provides the audible alarm. The buzzer will continue to sound (even with the removal of the sense signal) due to the holding or latched circuit condition above described until the voltage to the circuit 100 is interrupted by physically disconnecting or cutting off the supply voltage.

It will be observed that the circuit 100 is arranged for fail-safe operation should lamp 35 burn out. If this should happen, the lamp 35 will be open circuited and nearly the entire supply voltage will be across the neon tube so that it will automatically fire and activate the circuit to sound the alarm.

The capacitor 120 serves to provide a low reactance across the neon tube to steep-wave or high frequency signals that might be caused by transients in the supply voltage or other interference. Thus the capacitor 120 in series with resistor R2 acts as a filter to discriminate against high frequency pulses but has little effect at the operating frequency of sixty cycles per second.

Flame sense

Referring now to FIGS. 1, 2, 3, 5 and 6, light from a flame caused by a fire can enter one end of the transparent bulb of the neon tube through an aperture 19 in plate 18 on front cover 14. Some of this light which enters chamber 44 directly and not through chamber 32 or 33 or 42, falls directly on element P2 and when it is of sufficient intensity, it will actuate the circuit. Infra-red filter 26 may be positioned between the opening 19 in plate 18 and the neon tube to prevent fluorescent light (from lamp fixtures) and to some extent daylight, from actuating the circuit. To prevent the circuit from being actuated by incandescent light of high intensity in the event that the device is located or installed in the proximity of a bright incandescent light, a sensitivity control is provided. This control comprises the graduated holes or openings 19 in the disk or plate 18 which can be rotated. The plate 18 is located so that only one hole at a time can be aligned with the neon tube on line L, and a size of hole can be selected by rotating the plate, to adjust the sensitivity to flame detection with respect to ambient light which may prevail.

With light from a flame of sufficient intensity to cause the resistance of element P2 to fall to a value to trigger the neon tube, the circuit performs in exactly the same way as for smoke detection described above. It is possible to arrange the device so that light from a flame falls upon element P2 in other ways than the particular physical arrangement shown in the drawing. The device will however operate in the same manner as described above.

Heat sense

The circuit 100 operates for the heat sense in the same way as described for the smoke and flame senses. In heat detection, however, a transducer is employed which converts the heat signal to a light signal. This transducer is essentially the bimetallic element 55 operating in cooperation with a light source, namely lamp 35. Referring to FIGS. 3 and 5, the strip 55 of bimetal is mechanically and thermally attached to the heat pickup plate 52 which is exposed to radiation coming in to the device via slot 16. The bimetallic element 55 is shaped to present a flag or vane 60 at its free end. The flag is disposed in chamber 42 near chamber opening 44' and chimney opening 32'. When the bimetallic element 55 is bent rearwardly as viewed in FIG. 4 from the solid line position to the dotted line position, due to a rise in temperature, the flag is displaced to line of sight S and reflects light from lamp 35

through opening 44' to photoconductive element P2. In other words, as the bimetallic element heats up it bends such that the reflective part of it gets into the light path at chamber opening 32 and bends this path into chamber 44 through opening 44'. This provides the light signal on the sensing element P2; and when the light signal is sufficient in intensity to lower the resistance of element P2 to the point of firing the neon tube 48, the circuit performs as for the smoke and flame senses. Adjustment screw 59 is provided so that the heat detection sense can be set to be operative at any reasonable temperature value.

FIG. 7 shows an alternative construction which can be employed for heat sensing. Device 10a in FIG. 7 is substantially identical to device 10 and corresponding parts are identically numbered. A small hole 125 is drilled in block 38a between the photoconductive cell chamber 44a and light chamber 33a. The hole 125 is oriented in such a way that light from lamp 35 is reflected from the slanted walls of chamber 33a, enters hole 125 and by internal reflection therein passes to chamber 44a where the dual element cell 45 is located. A narrow slot 130 is cut at right angles to hole 125 in block 38a. The flag 60a on the free end of bimetallic element 55a is bent so that it can move in slot 130. With low temperature of bimetallic element 55a, the flag 60a will block hole 125. As the temperature of the bimetallic element 55a rises, it bends and moves flag 60a out of the light path through hole 125 until sufficient light impinges on element P2 to trigger circuit 100.

It will be noted that in both arrangements for the heat-light transducers 55 and 55a, no relay is employed and no relay contacts are required. These troublesome and expensive circuit components are omitted, but improved performance and reliability in operation result.

Lamp 35 which is continuously lighted when the device is in alert, operative condition, is arranged so that the device is fail-safe in the event of lamp burnout. If the lamp burns out the alarm will sound continuously as above described. The neon tube, photoconductive elements P1 and P2 and other components are normally deactivated, and actually operate only when the device senses one or more of the fire conditions above mentioned. Thus there is no danger that these components will fail due to overuse.

There has been described a first detecting device which has the following salient features among others:

(1) The light amplifier is self-triggering and employs a simple, inexpensive neon lamp. The self-triggering feature provides maximum protection from a fire.

(2) All three senses can be adjusted independently, i.e. resistor R1 is used to adjust the smoke sense response; rotatable plate 18 is used to adjust the flame-light response; bimetallic element 55 or 55a has adjustment screw 59 for adjusting the heat sense response.

(3) All three senses operate simultaneously and cooperatively, that is, additively, so that if the circuit 100 is partially activated, i.e. element P2 is partially reduced in resistance due to one fire condition (smoke, flame, or heat) the sensitivity of the device is automatically increased. It will now require a smaller change in resistance of element P2 in response to occurrence of one of the two remaining fire conditions to trigger the circuit. Stated otherwise, the total effect of the light signals due to all three senses is the sum of the effects produced by each of the three senses. The three light signals or any two of them are added together by the photoconductive element P2. This system provides maximum protection since the response to any one fire condition may not be sufficient to activate the alarm but the cumulative response to any two or all three possible fire conditions will generally be sufficient to activate the alarm.

(4) The thermal pickup plate 52 used for the heat sense is massive, has good thermal conductivity, low thermal inertia and good exposure to heat radiation. This together with the very light, instantly responsive, sensitive bimetallic strip in the heat-light transducer results in very fast response to an abnormal heat condition.

(5) A single photoconductive element (P2) acts for all three senses.

(6) The sensing circuit is self locking by means of the fired neon tube which illuminates the sensing element P2.

(7) The fired neon tube serves to trigger the alarm circuit as well as keep the sensing circuit locked in, even though the fire condition decreases in intensity after triggering the sensing circuit.

(8) The entire detector device is small in size and weight, automatic in operation, inexpensive to manufacture and simple to install, it avoids use of relays and relay contacts.

(9) The device uses very low power in continuous operation, only a few watts.

(10) The device can be easily tested for operativeness by applying a lighted match at one of openings for activating the light sense or flame sense; by blowing cigarette smoke through chimney 32 to activate the smoke sense; and by applying heat from a hair dryer or the like to activate the heat sense. Any one of these stimuli will stimulate a fire condition to activate the device and sound the alarm. Each will test a different sense.

(11) The device is readily adapted for remote alarm operation. The buzzer 70 can be replaced by a step-down transformer (e.g. 115 volts A.C. to 6 volts A.C.). A six-volts buzzer or other low voltage alarm can then be installed at a remote point and connected to the device by light bell wire.

(12) The only component in the device which is sufficiently loaded to burnout in time is lamp 35, but the fail-safe arrangement of the circuit 100 provides adequate protection in the event of such a burnout. Of course a proper schedule of inspection and maintenance including periodic replacement of lamp 35 will insure against occurrence of lamp burnout due to overuse.

What is claimed and sought to be protected by Letters Patent is:

1. A fire detector responsive to smoke, flame and heat conditions, comprising:

first and second photoconductive elements;

an electrically energized light source;

means defining first and second spaced chambers communicating with each other, said light source being disposed in said first chamber, said photoconductive elements being disposed in said second chamber in substantial darkness, said first photoconductive element being disposed so that it is shielded from light emitted by said light source, the second photoconductive element being disposed so that light from the light source can reach the second element only by traveling a bent optical path with reflection at a point in said path into the second chamber;

a gas discharge tube disposed in the second chamber for illuminating both photoconductive elements when the tube is fired;

an electrical power supply;

an electrically operated alarm device;

means connecting said alarm device and said first photoconductive element in a first direct series circuit with said power supply;

means connecting said tube and said second photoconductive element in a second circuit direct series circuit with said power supply;

means connecting said light source to said power supply in a third direct series circuit; and

a heat responsive member normally disposed between the first and second chambers and blocking the path of light between the light source and second photoconductive element,

whereby said heat responsive member moves upon being sufficiently heated to clear said path so that light from the light source passes along said path to illuminate the second photoconductive element,

whereby the gas tube is fired when light from the

light source reaches the second photoconductive element to reduce its electrical resistance, whereby light from the fired gas tube reaches the first photoconductive element to reduce its resistance and cause said alarm device to be energized, and

whereby light from the fired gas tube reaches the second photoconductive element to keep the gas tube fired even though light from the light source is thereafter cut off from the second photoconductive element.

2. A fire detector responsive to smoke, flame and heat conditions, comprising:

first and second photoconductive elements;

an electrically energized light source;

means defining first and second spaced chambers communicating with each other, said light source being disposed in said first chamber, said photoconductive elements being disposed in said second chamber in substantial darkness, said first photoconductive element being disposed so that it is shielded from light emitted by said light source, the second photoconductive element being disposed so that light from the light source can reach the second element only by traveling a bent optical path with reflection at a point in said path into the second chamber;

a gas discharge tube disposed in the second chamber for illuminating both photoconductive elements when the tube is fired;

an electrical power supply;

an electrically operated alarm device;

means connecting said alarm device and said first photoconductive element in a first direct series circuit with said power supply;

means connecting said tube and said second photoconductive element in a second circuit direct series circuit with said power supply;

means connecting said light source to said power supply in a third direct series circuit;

said first chamber having an orifice therein for passing smoke therethrough, so that light from said light source reaches the second photoconductive element by reflection from the smoke in said path;

aperture means for passing light from an external flame directly into said second chamber to illuminate only the second photoconductive element,

whereby the gas tube is fired when light from the light source reaches the second photoconductive element to reduce its electrical resistance,

whereby light from the fired gas tube reaches the first photoconductive element to reduce its resistance and cause said alarm device to be energized, and

whereby light from the fired gas tube reaches the second photoconductive element to keep the gas tube fired even though light from the light source is thereafter cut off from the second photoconductive element; and

a heat responsive member disposed in said path and movable with respect to said path to permit light to pass along said path to illuminate the second photoconductive element when said heat responsive member is heated;

whereby the response of the fire detector to said conditions is determined by the total intensity of light impinging on the second photoconductive element, said total intensity of light being the sum of individual light signals impinging on said second photoconductive element and comprising:

- (1) light reflected by smoke in said paths,
- (2) light permitted to pass along said path by heat responsive member when it is heated, and
- (3) light generated by an external flame and passing directly into said second chamber.

3. A fire detector as defined by claim 2, wherein said aperture means is adjustable, the adjustment of said aperture means determining the minimum intensity of light required from an external flame to illuminate the second photoconductive element for firing the gas tube; and further comprising adjustment means for said heat responsive member to determine the minimum temperature required to move said heat responsive member sufficiently to effect the intensity of light passing along said path.

4. A fire detector as defined by claim 2, further comprising a variable resistor connected between the second and third circuits, for setting the firing voltage of the gas tube in accordance with a predetermined density of smoke in the first chamber, said light source being a lamp having such an electrical resistance connected in parallel with the gas tube that the gas tube normally remains extinguished, whereby sufficient voltage is applied to the gas tube via said variable resistor to fire the gas tube in the event that the lamp burns out, so that the first photoconductive element than becomes illuminated and the alarm device becomes energized to signal that the lamp is burned out.

5. A fire detector according to claim 2, wherein said aperture means is adjustable, the adjustment of said aperture means determining the minimum intensity of light required from an external flame to illuminate the second photoconductive element for firing the gas tube.

6. A fire detector according to claim 2, and adjustment means for said heat responsive member to determine the minimum temperature required to move said heat responsive member sufficiently to affect the intensity of light passing along said path.

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U.S. Cl. X.R.

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