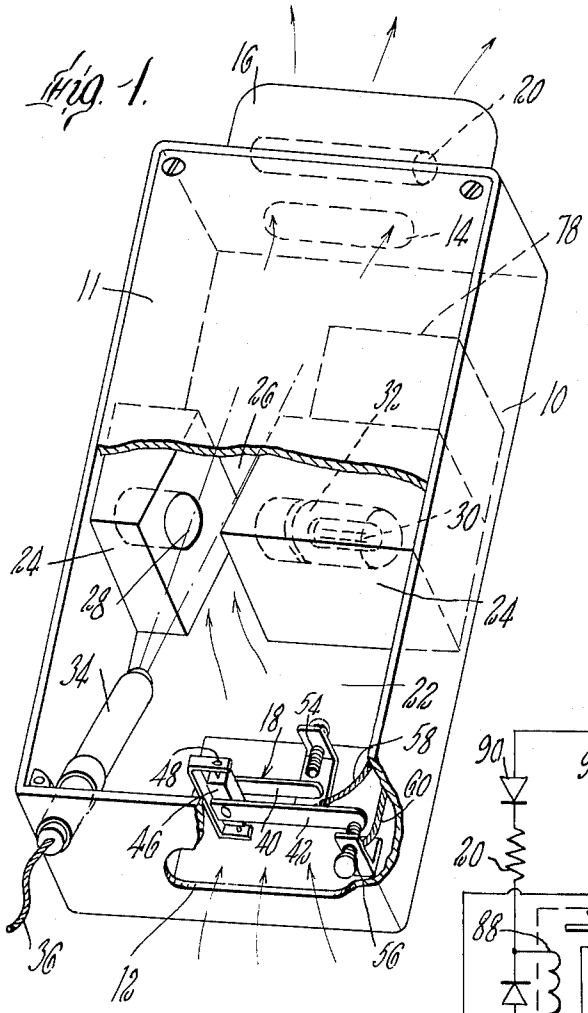
Dec. 7, 1965 P. GIUFFRIDA 3,222,662

SIGNALLING APPARATUS INCORPORATING A DIFFERENTIAL RELAY

Filed Dec. 27, 1961

Fig. 1.



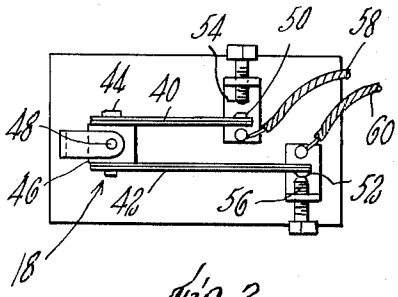


Fig. 2.

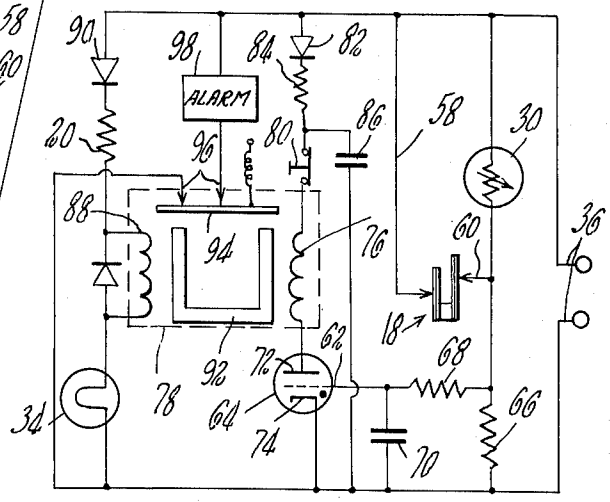


Fig. 3.

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SIGNALLING APPARATUS INCORPORATING A DIFFERENTIAL RELAY

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This invention relates to fire detection apparatus.

Numerous different types of apparatus have been proposed for performing fire detection functions which operate on a variety of principles. Among these are devices which employ heat sensing elements such as bimetallic members, flame sensing elements such as those sensitive to either infra red radiation or ultraviolet radiation, and smoke detecting arrangements. Conventional fire detectors include a sensor that is responsive to a particular effect associated with smoke, temperature or flame. Both for reliability of fire detection and for greater versatility and less criticality in application, it is desirable that a fire detector be responsive to more than one particular fire condition. For example there are combustible materials which may give off large quantities of smoke without great increase in temperature, while the burning of other materials generates a substantial temperature increase without producing much smoke. Further, in many cases flame will be obscured, at least at early stages of the fire, from the sensor element. In such situations a single sensor type of detector must be carefully engineered for application in appropriate environments only and care must be taken in placing the detector in those environments to insure that the detector will respond to the type of fire that is likely to occur. Even then continued checks on the protected area should be maintained, so that the detection apparatus may be revised if the nature of fire producing materials located in the area is changed, for example. In many cases such continued checks are unfeasible from an economic viewpoint and a more versatile fire detector is desirable.

Accordingly, it is an object of this invention to provide a novel and improved fire detection apparatus incorporating a plurality of different fire condition sensor elements.

Another object of the invention is to provide a compact, reliable and relatively inexpensive fire detection unit responsive to both heat and smoke conditions.

Still another object of the invention is to provide in a fire detection apparatus reliable electrical circuitry incorporating checking circuitry providing a signal on the failure of the less reliable components of the circuitry.

In a preferred embodiment constructed in accordance with principles of the invention there is provided a detector unit having a casing defining a passageway adapted to be substantially vertically disposed. The passageway includes a lower or entrance aperture adjacent which a heat sensor is mounted; an upper or exit aperture adjacent which an airflow inducing elements is mounted; and an intermediate restriction across which a particle (smoke) sensor is disposed for scanning air flowing through the passageway. Also mounted within the casing is electrical circuitry for operating the heat and particle sensors and a common alarm system that is responsive to both the heat sensor and the particle sensor, so that a compact fire and smoke detector unit which generates an output signal in response to a plurality of different fire characteristics is provided. The output signal may operate an alarm or associated equipment as desired.

In the preferred embodiment of the invention the heat sensor includes a completely exposed, compensated bimetallic element and the particle sensor includes a photocell arrangement which senses light reflected from particles in the air flowing through the unit. Electrically the particle sensor includes a cadmium selenide photocell that is connected in circuit with the bimetallic element so that a signal from either of these devices is applied to the control grid of a cold cathode thyratron arranged to energize one coil of a two coil differential relay to provide an output signal. The one coil is in the anode circuit of the thyratron and the second coil of the relay is connected in series circuit with the particle sensor light source and the heater (air flow inducing) element so that if either fails the second relay coil is deenergized and a warning signal is generated. Reset means, connected in the thyratron anode circuit enable the circuit to be reset after operation in response to the particle or heat sensors but prevents resetting if the component elements are defective.

The invention provides a comparatively inexpensive and reliable fire detector apparatus in a compact assembly of sensor elements responsive to a plurality of fire indicating conditions. The apparatus provides an output signal in response to the detection of an abnormal condition indicative of a fire and also signals failure of components within the apparatus. It is a compact apparatus that has versatility in application and does not require extensive scheduled maintenance.

Other objects, features and advantages of the invention will be seen as the following description of a preferred embodiment thereof progresses in conjunction with the drawing, in which:

FIG. 1 is a perspective view, partially in section and partially diagrammatic, of a fire detecting unit constructed in accordance with the principles of the invention;

FIG. 2 is an elevational view illustrating certain features of the heat sensor unit employed in the preferred embodiment of the invention; and

FIG. 3 is a schematic diagram of the electric circuit employed in the fire detector unit illustrated in FIG. 1.

With reference to FIG. 1, the fire detector unit includes an enclosure or casing **10** which houses the senor elements, associated electrical circuitry and alarm device. The casing has a cover **11** which can be easily removed for access to components within. The casing, which is adapted to be disposed in substantially vertical position, has a lower entrance aperture **12** and an upper exit aperture **14** above which is disposed a chimney-like structure **16**. A passageway through the casing connects the entrance and exit apertures. Disposed immediately inside the casing above the entrance aperture is a heat sensor **18** and disposed in the chimney **16** is a heat producing unit in the form of an electrical resistance element **20**. This element **20** tends to produce a flow of air through the casing passageway from the entrance aperture to the exit aperture by thermal convection.

At an intermediate point in the chamber **22** formed by the passageway there is a restricted area formed by protruding members **24** which extend from the casing walls and define a relatively narrow gap **26** through which the air flowing through the passageway must pass. Across this gap a particle sensor is disposed. Formed in one of the protrusions on one side of the gap **26** is a cylindrical depression **28** with its interior surface coated with black material or otherwise rendered suitably non-reflecting.

In the other protrusion on the opposite side of the gap is a cadmuim selenide photocell **30** and associated optics **32** disposed to scan across the gap towards the non-reflecting well **28**. A light source **34** mounted within the lower portion of the casing has its focused light beam aimed to pass through the gap **26** substantially normal to the scanning direction of the photocell. As indicated in FIG. 1 the radiation from the source **34** is beamed in a

slightly diagonal direction across the chamber but substantially parallel to the path of air flow through the chamber so that light reflected by particles in the air flowing past the gap will be sensed by photocell **30**. Power for the unit is supplied over lines **36** from a suitable household 110 volt source, for example.

The heat sensor element **18**, as shown in FIGS. 1 and 2, comprises two bimetallic elements **40**, **42** that are completely exposed to air flow and hence will rapidly respond to temperature changes in the supervised environment. The sensor is mounted directly below the photocell housing **24**. The bimetallic element **40** has a larger mass but is shorter than element **42**, being approximately 75% of the length of that element. The two elements are secured by suitable means such as rivets **44** to a block **46** mounted on pivots **48** such that they are free to move as a unit. Electrical contacts **50**, **52**, carried at the free ends of the bimetallic elements **40**, **42**, respectively, cooperate with adjustable stationary contacts **54**, **56** respectively, which are connected to the electrical circuit by leads **58**, **60**. Initially those contacts are adjusted with one set of contacts closed to a suitable clearance at the other set of contacts, such as 0.010 inch.

This heat sensor has its bimetallic leaf elements directly disposed in the flow of air through the fire detector casing. When the detector elements **40**, **42** are exposed to a sudden blast of hot air the bimetallic element **42** having the smaller mass will move more rapidly than the compensator element **40** and will close the circuit between the contacts **52**, **56** to energize lines **58**, **60**. However, in response to a gradual rise in temperature the compensator leaf **40** will move in response to the increased temperature at a rate related to, but somewhat slower than, the movement of the actuator leaf **42** and pivots the block **46** so that at a temperature between 150° F. and 185° F. (depending on the initial setting of the contacts) the heat sensor circuit will be closed to provide an alarm signal.

With reference to the electric circuit shown in FIG. 3, the particle or smoke sensor cell **30** (type 408) and the heat sensor **18** are connected in parallel to the input circuit of the starter electrode **62** of a cold cathode thyratron **64** (type 5823). Resistors **66** and **68** and capacitor **70** provide an input coupling network of the signals to the starter electrode **62**. When the starter electrode **62** is energized the thyratron will conduct current via the anode **72** and cathode **74**, energizing relay coil **76** of the differential relay **78**. Also connected in the anode circuit of the thyratron is a reset switch **80**, a rectifier **82**, a resistor **84** and a capacitor **86**.

A second coil associated with the differential relay **88** is connected in series between the lamp **34**, the heater element **20** and a rectifier **90**. A flux conducting element **92**, magnetically coupled to both the relay coils **76** and **88**, controls the position of an armature **94** which operates a set of normally closed contacts **96** to control the energization of alarm **98**.

When the fire detector is supplied with power and, provided the lamp **34**, resistor **20**, relay coil **88** and rectifier **90** are all in working order, flux is induced in the element **92** to move the armature **94** and open the contacts **96**, thus de-energizing the alarm unit **98**. Should any of these series connected elements be defective so that the circuit cannot be completed the alarm circuit will be energized indicating that a failure has occurred.

Until a smoke condition is detected by the cell **30** or a temperature condition is detected by heat sensor **18**, no current flows in coil **76** and the relay contacts **96** remain open under the influence of the flux from coil **88**. When thyratron **64** becomes conductive, however, current flows in coil **76**, producing a flux that cancels the effect of the flux from coil **88** so that the armature **94** closes contacts **96** energizing the alarm unit **98**. The flux produced by the two coils are proportioned so that they are equal and opposite and hence cancel. After the thyratron is fired the alarm circuit will continue to be energized even though the cause of the alarm signal from the sensor (or sensors) may terminate since the thyratron is connected to a D.C. source and extinguishes itself only when that source is removed. The anode circuit may be opened by the reset button **80** which de-energizes the thyratron and allows the alarm contacts **96** to open under the influence of coil **88**.

Thus it will be seen that the invention provides a compact, reliable fire detention unit suitable for home or factory fire detection installations, which employ a plurality of different fire condition sensors. In the disclosed embodiment smoke detection means is provided that operates on the principle of reflected light and will respond to a light obscurity condition of approximately 10%, while heat sensor means is provided that responds either to a temperature value or to a rate of temperature change, either response being adjustable as a function of the type of fire environment in which the detector is placed, for example. The circuitry positively responds when either a temperature or a smoke condition is detected and maintains an alarm condition independently of the sensor condition after initial detection of such a fire condition until the circuit is manually reset. The circuit components provide a reliable system employing only a single active element (a thyratron) which is energized only upon detection of a fire condition to sound the alarm. The circuitry is substantially maintenance free except for the need to periodically replace the light source and the circuitry is arranged to automatically provide an alarm when that element fails.

While a preferred embodiment of the invention has been shown and described, modifications thereof will be obvious to those skilled in the art and therefore it is not intended that the invention be limited to the disclosed embodiment or to details thereof and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

I claim:

1. A signaling apparatus comprising a casing, having an entrance aperture and an exit aperture,
said casing defining a passageway between said entrance aperture and said exit aperture, allowing a substantially unrestricted flow of air through the casing,
a particle sensor including a light radiation sensor disposed for scanning the air flow through said passageway,
and a light radiation source having a beam directed generally perpendicular to the scanning direction of said radiation sensor and across the scanned area,
a heat sensor disposed adjacent said entrance aperture,
a gain producing element,
a two coil differential relay including contacts controlled by said relay connected in circuit with an alarm,
means connecting one coil of said differential relay in electric series circuit with said gain producing element and the other coil of said differential relay in electric series circuit with said radiation source,
first electric circuit means connecting said radiation sensor and said heat sensor in parallel, second electric circuit means connecting said first electric circuit means to said gain producing element to control the operation of said gain producing element,
said differential relay operating said relay control contacts to produce an alarm signal in response to operation of said gain producing element or failure of said radiation source.

2. The apparatus as claimed in claim **1** wherein said heat sensor is a bimetallic structure having a pair of bimetallic elements positioned immediately above said entrance aperture,
said pair of bimetallic elements being mounted for pivoting movement as a unit,

one of said bimetallic elements being an actuator member and the other of said bimetallic elements being a compensator member of substantially greater mass than said actuator member.

3. A signaling apparatus comprising a casing having an entrance aperture, an exit aperture and a passageway between said entrance and exit apertures which allows a substantially unrestricted flow of air through the casing,

a particle sensor disposed in said casing including a photocell disposed for scanning the air flow through said passageway,

and a light source having a focused beam directed generally perpendicular to the scanning direction of said photocell and across the area scanned by said photocell so that light reflected from particles in the air flow through said passageway may be detected by said photocell,

a heat sensor including a bimetallic element mounted immediately adjacent said entrance aperture and a fixed contact,

said bimetallic element carrying an electrical contact adapted to cooperate with said fixed contact,

means for producing air flow through said passageway past said heat sensor and said particle sensor,

an electronic switching element having an input circuit and an output circuit,

a differential relay having a first coil connected in electric circuit with the output circuit of said electronic switching element,

a second coil connected in series circuit with said light source,

and a set of relay contacts,

an alarm circuit connected to said set of relay contacts,

said second coil of said differential relay being connected to produce via said set of relay contacts, a signal in said alarm circuit in response to failure of said light source,

and electric connector means for connecting said photocell and said fixed contact in parallel to the said input circuit of said electronic switching element to operate said electronic switching element in response to a fire condition sensed by either said particle sensor or said heat sensor and produce a signal in said first coil of said differential relay for providing a signal in said alarm circuit via said set of relay contacts.

4. A signaling apparatus comprising a casing defining an entrance aperture, an exit aperture and a passageway between said entrance and exit apertures which allows a substantially unrestricted flow of air through the casing,

a particle sensor disposed in said casing including a photocell disposed for scanning the air flow through said passageway,

and a light source having a focused beam directed generally perpendicular to the scanning direction of said photocell and across the area scanned by said photocell so that light reflected from particles in the air flow through said passageway may be detected by said photocell,

a heat sensor including a pair of bimetallic elements mounted in parallel relation for pivoting movement as a unit immediately adjacent said entrance aperture and a pair of fixed contacts,

each bimetallic element carrying an electrical contact adapted to cooperate with the corresponding fixed contact,

means for producing air flow through said passageway past said heat sensor and said particle sensor,

a thyratron tube having an anode element and a control element,

a differential relay having a first coil connected in electric circuit with said anode element of said thyratron tube,

a second coil connected in series circuit with said light source and said means for producing air flow,

and a set of relay contacts,

an alarm circuit connected to said set of relay contacts,

said second coil of said differential relay being connected to produce via said set of relay contacts, a signal in said alarm circuit in response to failure of said light source or said means for producing air flow,

and electric connector means for connecting said photocell and said pair of fixed contacts in parallel to the said control element of said thyratron tube to operate said thyratron tube in response to a fire condition sensed by either said particle sensor or said heat sensor and produce a signal in said first coil of said differential relay for providing a signal in said alarm circuit via said set of relay contacts.

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