Dec. 27, 1955 W. J. SCHAFER 2,728,904

SUPERVISED FIRE DETECTION AND ALARM SYSTEM

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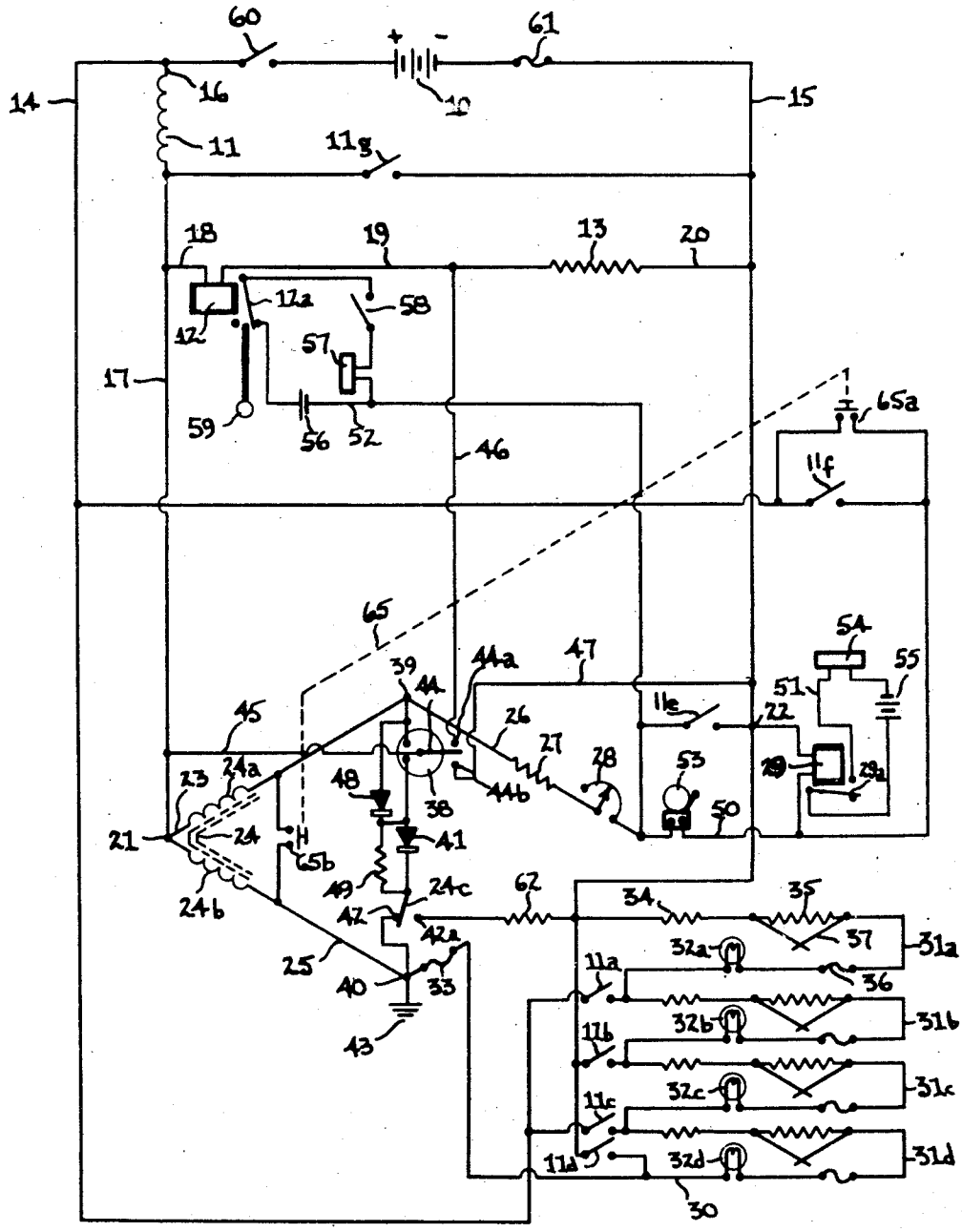


FIG. 1

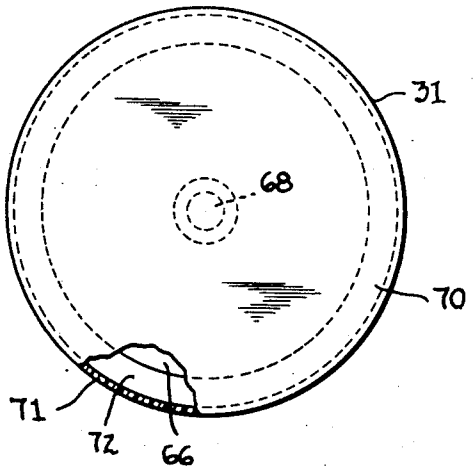
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FIG. 2



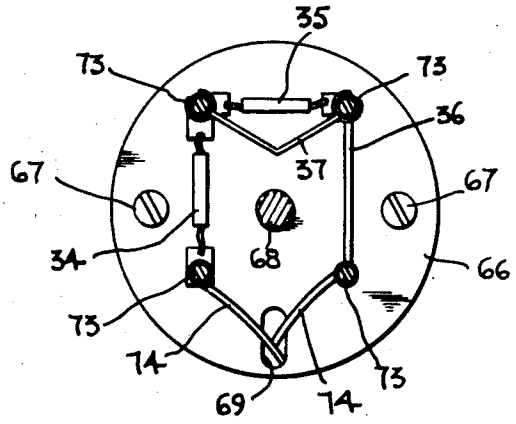


FIG. 3

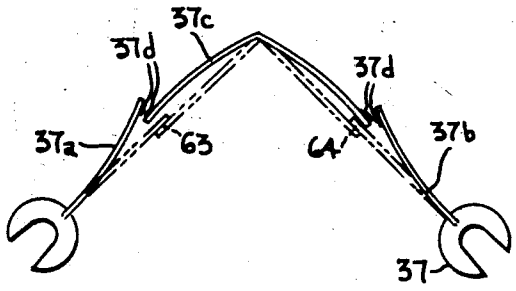


FIG. 4

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United States Patent Office 2,728,904
Patented Dec. 27, 1955

2,728,904

SUPERVISED FIRE DETECTION AND ALARM SYSTEM

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Application June 29, 1954, Serial No. 440,009

3 Claims. (Cl. 340—227)

This invention relates in general to an electrically energized system for sensing abnormal conditions of temperature, and is a continuation-in-part of my copending application, Serial No. 402,745, filed January 7, 1954 and bearing the same title. More particularly, this invention relates to a fire alarm or signalling system having improved means for sensing and signalling the existence of operative defects and disturbances in the system so that the operative condition of the system is automatically and continuously supervised.

It is apparent that an automatic fire detection system, which is incapable of functioning properly when the need arises, is worse than having no system at all. The existence of an inoperative automatic fire detection system on occupied premises gives the occupants a false sense of security which blunts their vigilance and alertness and thus can easily result in a condition where total reliance is placed in the system, with tragic consequences.

It is a primary object of my invention to provide an automatic fire detection system of the character described which is self-supervising, whereby it will detect and indicate any serious condition of inoperativeness of the system.

Another object of my invention is to provide a fire detection system in which said supervision is automatically and continually maintained.

Still another object of my invention is to provide a fire detection system in which the signal indications for fire conditions are distinct from the signal conditions resulting from operative defects or disturbances.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same,

Fig. 1 is a schematic wiring diagram of a supervised fire detection system embodying the features of my invention.

Fig. 2 is a plan view of a thermal unit which may be utilized in the fire detection system.

Fig. 3 is a view similar to Fig. 2, with the cover of the thermal unit removed to show the arrangement of the circuit elements.

Fig. 4 is a diagrammatic view showing the operation of the fuse element which is employed in the thermal unit.

Referring more particularly to Fig. 1 of the drawings, I have shown a fire detection system which includes a source of power supply **10** which is preferably independent of the usual power supply of the structure to be protected, and can conveniently be a low voltage dry cell battery rated, for example, at nine volts.

The system may, for convenience, be considered as consisting of a power circuit, a detection and control circuit, and the subsidiary signal or alarm circuits, all of which are fully described hereinafter.

The power circuit is connected in series with the battery **10** and includes a control relay **11**, a voltage relay

12, and a resistor **13**. The resistor **13** is included in the circuit to reduce the current value of the power circuit to a point where it is incapable of actuating the relay **11**, while at the same time permitting a sufficient value of current to cause energization of relay **12**. It will be understood that in selecting the resistor to be used, consideration must be given to the electrical characteristics of the other power circuit elements so as to obtain the functional condition, mentioned above. Such selection is within the knowledge of one skilled in the art. In the illustrative example of Fig. 1, the resistor **13** may have a value of 2000 ohms in relation to relay **11** of 50 ohms and relay **12** of 2500 ohms.

For clarity of description, the conductors in the power circuit will be identified as follows: **14** is the bus line from the positive side of the battery **10**; **15** is the bus line from the negative side of the battery; **16** is the lead connecting relay **11** to the positive side of battery **10**; **17** is the conductor connected to the negative side of relay **11**; **18** is a lead connecting relay **12** to lead **17**; **19** is the lead between relay **12** and resistor **13**; and **20** is a lead connecting resistor **13** to negative bus line **15**.

The detection and control circuit is connected across the battery **10** in series with the relay **11** and in parallel with the relay **12** and resistor **13**. This circuit includes a Wheatstone bridge connected at **21** to lead **17** and connected at **22** to the negative side of the power circuit. The resistance value of the Wheatstone bridge prevents energization of the relay **11** through this circuit.

One arm **23** of the bridge includes one coil **24***a* of a differential relay **24**, the other coil **24***b* of the relay being disposed in an arm **25** of the bridge. A third arm **26** includes a resistor **27**, a variable resistance or rheostat **28** and an external alarm relay **29**. The fourth arm **30** of the bridge includes one or more thermal detector units **31** (as shown in Fig. 3) connected in series with each other and with signal units **32** which, in this example, are lamps **32***a*, **32***b*, **32***c* and **32***d*.

Each thermal unit **31** is physically located in a specific detection area of the structure to be protected, and as many thermal units may be used as are necessary to provide adequate overall protection. Fig. 1 illustrates four of such thermal units **31***a*, **31***b*, **31***c* and **31***d*. The arm **30** also includes a fusible link **33**.

Each thermal unit includes a resistor **34** connected in series with a second larger resistor **35** which is, in turn, in series with a fusible link **36**. The resistor **34** may, for example, have a value of 15 ohms and the resistor **35** may be 300 ohms. Connected in parallel across each resistor **35** is a thermo-mechanical fuse or circuit breaker **37**, which will be described in more detail hereinafter. Each thermal unit is in series with one of the lamps **32**, which are preferably centrally located and consolidated on a control panel which is remote from the thermal units **31**.

In addition to the series arrangement of the thermal units **31**, an alternate parallel circuit is provided in which the units **31** are individually connected across the bus lines **14** and **15**. These parallel circuits are established by the closing of the normally-open plural contacts **11***a*, **11***b*, **11***c* and **11***d* of relay **11**.

A sensitive relay **38** of the galvanometer type is connected across the Wheatstone bridge, as at **39** and **40**, in series with a current rectifier or diode **41** which may be of the germanium detector type. A contact arm **24***c* of the differential relay **24** is also in series with the relay **38** and normally serves to complete the circuit across the points **39** and **40** of the Wheatstone bridge by means of its engagement with lead contact **42**. The bridge is preferably grounded as at **43**.

The relay **38** is provided with a movable pointer or

switch arm 44 which will indicate the condition of balance or unbalance existing in the Wheatstone bridge circuit. The relay 38 has double contacts 44*a* and 44*b* which are engageable by arm 44 in response to current flow in one direction or the other. The pointer 44 is connected to positive conductor 17 by means of a lead 45. The contact 44*a* is connected in parallel with relay 12 by means of lead 46. The contact 44*b* is connected to negative bus line 15 by means of a lead 47 to provide a shunt circuit across relay 12 and resistor 13.

A second diode 48 is connected across the sensitive relay 38 and also connects with a resistor 49 which is connected across diode 41.

The foregoing describes the essential elements of the detection and control circuit.

The signal or alarm circuits may be designated as an internal alarm circuit 50, an external alarm circuit 51 and a trouble alarm circuit 52.

The internal alarm circuit 50 includes a bell 53, or other suitable audible alarm, which may be located in a convenient central location in the building or structure to be protected. The bell and relay 29 are circuit elements of the arm 26 of the Wheatstone bridge. The internal alarm circuit is closed by the relay-actuated contacts 11*e* and 11*f* which serves to energize the bell 53 and relay 29, respectively. During normal operation, there is insufficient current flow through the arm 26 to cause actuation of the bell 53 or relay 29.

The external alarm circuit 51 includes any form of signal or indicator element, which may be physically remote from the protected structure. As exemplary of such an element, I have shown a siren 54 which is connected in series with an independent power supply 55. The circuit includes a relay-actuated switch arm 29*a* which is normally maintained in open position, but which closes the circuit when relay 29 is energized.

The trouble alarm circuit 52 is also preferably provided with an independent power supply 56 which may be a mercury cell or the like, and which serves to energize an audible alarm such as a buzzer 57. A single-pole single-throw normally open switch 58 is provided in the circuit. The circuit is closed by a relay-actuated switch arm 12*a* which is usually maintained in open position in response to energization of relay 12.

Although it is not an electrical element of the trouble alarm circuit 52, I have diagrammatically indicated at 59 a drop flag or target which may be utilized as a visual indication of deenergization of the relay 12 in a manner well known in the art. The drop flag 59 is useful in recording the fact that a trouble condition has existed, even though the condition may have somehow remedied itself and thus reopened the trouble alarm circuit.

The alarm operation of the above-described system is based upon the creation of a condition of unbalance in the Wheatstone bridge circuit. Therefore, when the system is operating normally, the Wheatstone bridge is in balance, i. e., the resistance values of the arms 23 and 26 is equal to that of arms 25 and 30. The rheostat 28 which may be rated, for example, at 0–300 ohms, has a sufficient range to permit the system to be adjusted to a balanced condition so that no current will flow through relay 38, and therefore pointer 44 will lie intermediate the contacts 44*a* and 44*b*.

A main switch 60 is provided in the power circuit, and preferably it is fused as at 61. When switch 60 is closed, current will flow through the power circuit to energize relay 12 and thus keep switch arm 12*a* from closing the trouble alarm circuit 52. However, the current value in the power circuit is insufficient to actuate relay 11 and therefore all of the relay contacts 11*a*, 11*b*, etc. will remain open. A supervisory current will flow through the detection circuit which includes the thermal units 31 and the lamps 32. The detection circuit is thereby constantly supervised during normal operation, and visual indication of such supervision is provided by the lamps 32. In the absence of the alternate parallel thermal unit circuit previously described, any failure of the circuit elements of the thermal arm 30 of the Wheatstone bridge or of relay 11 would cause the lamps 32 to be extinguished and thus indicate such failure. However, it is desired not only that the system indicate that a failure has occurred, but also that it indicate, whenever possible, the approximate location of the failure as well as its nature or character, so that it can be distinguished from a fire failure. This attribute of the supervised system is best explained by describing the operation of the system under the various conditions to which it may be subjected.

First, I will discuss some of the trouble or failure conditions which might occur independently of a fire condition, and which would generally cause the system to be inoperative unless the condition is noted and remedied.

One of the conditions which might occur, is that resulting from a complete failure of the power supply circuit. This might be caused by a break in the power circuit lines, such as line 15, for example. Or it might result from a short circuiting of the battery 10. Or, if a community power supply is being used, it may be caused by some external source. Upon power supply failure, the voltage relay 12 is deenergized, and the switch arm 12*a* is thereby released to close the trouble alarm circuit 52, and cause the buzzer 57 to be energized. At the same time, the flag 59 will drop. As soon as notice has been taken of the buzzer 57, the circuit 52 may be opened by means of normally-closed manual switch 58, as illustrated in Fig. 1, to prevent unnecessary depletion of the cell 56. It will be noted that the power failure causes no actuation of the sensitive relay 38. Therefore, an inspection of the position of the pointer 44*a* will clearly show that the trouble does not lie in an arm of the Wheatstone bridge, but elsewhere in the system. If the power failure is only temporary or of short duration, the trouble alarm circuit 52 will be opened by the energization of relay 12 as soon as the power supply is restored, and the buzzer will be silenced. However, the position of the flag 59 will indicate that a temporary power interruption has occurred.

In the event the battery 10 weakens or deteriorates through age or use, the system will react in the same manner as it does to power failure. The relay 12 may be selected to be inoperative when the power voltage decreases below a certain percentage of its normal rating. Thus, for example, when the battery power drops from a normal nine volts to about five volts, the relay 12 will no longer be effectively energized and the trouble circuit 52 will be established. In this manner, the eventual failure of the battery can be anticipated, and timely replacement can be made. It is to be noted, however, that the control relay 11 may be selected to be operative at voltage levels which will exist when relay 12 and resistance 13 are shunted out of the power circuit (in a manner to be described more fully hereinafter) so that, in effect, the system will still be operative for fire detection even when the trouble circuit 52 indicates that the battery 10 needs replacement.

Another form of trouble condition could be caused by a short circuit in the thermal arm 30 of the Wheatstone bridge, which would eliminate some of the resistance elements in this arm. Under such circumstances, the cathode of the diode 41 is negative and the diode acts like a relatively low resistance permitting current to flow through relay 38 and cause deflection of pointer 44 toward contact 44*a*. When the contacts are closed, a shunt circuit is established across relay 12 which short circuits the relay and causes it to become inoperative. This, in turn, causes the trouble circuit 52 to be established in the manner previously described. After the short circuit is found and remedied, the pointer 44 is reset to its neutral position and the relay 12 will then become energized to

cause the trouble alarm circuit **52** to be opened. The shunting effect of diode **48** on sensitive relay **38** is negligible due to the relatively low resistance of the relay **38**.

When there is a break in the alarm arm **26** of the circuit, the anode of the diode **41** becomes positive and the system reacts in the same manner as it does to a short-circuit in the thermal arm **30**.

Another trouble condition may occur when there is a break in the thermal arm **30**. This causes the cathode of diode **41** to go positive thus causing it to become non-conducting. However, some current will flow through the parallel resistor **49** and this will cause a very slow movement of pointer **44** toward contact **44*b***. At the same time, the open thermal arm will cause effective elimination of the bucking flux of the coil **24*b*** of the differential relay **24** which holds contact arm **24*c*** against contact **42**. The arm **24*c*** is thereby actuated to make contact with a contact lead **42*a*** which connects diode **41** with the negative side of the power supply through a high resistance **62** which is provided to prevent a dangerous level of current flow through the sensitive relay **38**. The diode then will permit current to flow through relay **38** to cause the pointer arm **44** to swing in the opposite direction and make contact with **44*a*** before there has been time for it to make contact with **44*b***. The relay **12** is thus shorted out and the circuit **52** is established to visually and audibly indicate the existence of the difficulty.

The foregoing represents the principal trouble conditions which are detected by the system, and which are indicated by a signal which is distinct from the alarm which is given when a fire condition exists, so that there should be no undue panic due to false alarms.

If an uncontrolled fire condition should develop in any area which is supervised by a thermal unit **31**, the increase in ambient temperature will cause the fuse element **37** to open. As best seen in Fig. 4, the element **37** includes three sections **37*a***, **37*b*** and **37*c*** which are joined or bonded to each other at their terminal junctures **63**, **64** by a low-melting fuse metal **37*d***. The sections **37*a*** and **37*b*** which are each connected to the resistor **35** are made of electro-conductive material which is pre-stressed during the assembly so as to cause the sections **37*a*** and **37*b*** to diverge at points **63** and **64** when the fuse metal becomes plastic or melts. The intermediate section **37*c*** is also electro-conductive and is pre-stressed during assembly so that its arms will converge toward each other when the fuse metal **37*d*** becomes plastic. This arrangement provides a snap action fuse element which is not subject to the vagaries which are encountered in using a simple fusible link, such as **36**, and which therefore responds more efficiently and more precisely to the temperature condition to which it has been calibrated. However, fusible link **36** is retained in the circuit as an additional safeguard.

The fuse element **37** which normally short-circuits a resistor **35**, causes the resistor **35** to be placed in series in the thermal circuit whenever a fuse element **37** opens, and thus adds about 300 ohms of resistance to the thermal arm **30**. This increase in resistance causes the cathode of diode **41** to become positive and the diode becomes non-conductive. The current then flows through resistance **49** and relay **38**, in the manner heretofore described, to cause pointer arm **44** to swing slowly toward contact **44*b***. In this instance, however, the increased resistance of the thermal arm **30** is not of great enough magnitude (as distinguished from the open condition) to cause actuation of contact arm **24*c*** of differential relay **24**.

When contact **44*b*** is made, a short-circuit is established across relay **12** and resistor **13**. The elimination of the resistance of the elements **12** and **13** from the power circuit causes actuation of control relay **11** to close the multiple contacts **11*a*—11*f***, previously described, as well as a contact **11*g*** which serves to assure continued energization of relay **11** even if there should be a subsequent

interruption or failure of the circuit established by the pointer arm **44** and contact **44*b***.

The actuation of the contacts **11*a*—11*d*** establishes the parallel thermal unit circuits **31*a*—31*d***, previously described. If, for example, the fuse element **37** of thermal unit **31*c*** has opened, the lamp **32*c*** will be substantially extinguished. However, the remaining lamps **32*a***, **32*b*** and **32*d*** will be in parallel and will be lit. Thus, the affected area can be determined quickly.

The closing of contacts **11*e*** and **11*f*** causes internal alarm circuit **50** to be energized and causes bell **53** to sound. The energization of relay **29** closes the external alarm circuit **51** and causes the siren **54** to be actuated.

The short-circuiting of the relay **12** also causes the trouble circuit **52** to be established. Thus a fire condition will cause two separate independently powered alarm circuits to be activated, in addition to the trouble circuit **52**. This condition (fire) is thus clearly and readily distinguished from the various trouble conditions.

The actuation of control relay **11** causes a momentary polarized voltage surge which tends to swing pointer **44** away from contact **44*b***. By placing the diode **48** in parallel with the relay **38**, the diode absorbs the bulk of the surge and prevents the breaking of the connection with contact **44*b***.

A manually operable sequential push-button switch **65** is provided for testing the external alarm circuit **51** and relay **29**, as well as serving as a manual burglar alarm system or the like. One set of contacts **65*a***, short-circuits the relay contact **11*f*** and serves to close the circuit to relay **29**. A second set of switch contacts **65*b*** short circuits the relay **38** and diodes in the Wheatstone bridge to prevent any actuation of the relay **38**. The switch **65** is designed to close the contacts **65*b*** before closing the contacts **65*a***.

From the foregoing it will be apparent that I have provided a supervised fire detection system which normally is in a condition of electrical balance. When the balance is destroyed by a moderate decrease in resistance in the thermal arm of the system or by an infinite increase (break) in the resistance of the thermal arm or alarm arm, a trouble alarm circuit will be actuated. However, a moderate increase in the resistance of the thermal arm will establish independent and distinctive local and remote alarm circuits in addition to the trouble alarm circuits, so that a fire condition is clearly emphasized and distinguished from a trouble condition.

Additionally, means have been provided for safeguarding continued operation of the control relay after a fire condition has been detected, and means have also been provided for testing or operating an external signal or alarm independently of the other circuits and without disturbing them.

In Figs. 2 and 3 I have shown a form of thermal detector unit **31** which may be utilized in the system herein described. The thermal unit **31** includes a base **66** which is adapted to be secured to a surface, such as a wall or ceiling, by means of fasteners **67**. The base **66** is preferably molded of a rigid synthetic resin and has integrally formed thereon a centrally projecting stud **68**. An aperture **69** is provided in the base for passage of the conductor wires or cable.

A circular cover **70**, also preferably formed of molded synthetic resin, is threadedly secured to the stud **68**. The cover is provided with an annular flange **71** having a larger diameter than the base **66**, so that an unobstructed annular space **72** is provided for circulation of air.

Secured to terminal posts **73** on the base, are the resistor **34** in series with link **36** and with fuse element **37** which is connected in parallel with resistor **35**. Conductor wires **74** serve to connect the thermal unit **31** with the other circuit elements of the system.

The cover **70** prevents foreign articles or particles from accidentally injuring the elements of the thermal unit

while at the same time permitting circulation of air through the unit.

It will be understood that all the components of the system, except the thermal units **31** and the external alarm **54**, may be physically grouped in a central control box or the like. The lamps **32** may be associated with suitable indicia of area location.

It is to be understood that the form of my invention, herewith shown and described, is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of my invention, or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. In a fire detection system of the character described, the combination of an electrical power supply, a balanced resistance circuit connected to said power supply, an alarm element in one arm of said circuit, a first switch means for connecting said alarm element directly to said power supply, a thermo-responsive detection unit in an opposed arm of said circuit, a sensitive relay in said circuit energizable in response to a condition of unbalance resulting from a change in the resistance value of either of said arms of said circuit, a control relay in series with said balance resistance circuit and actuated in response to a current value greater than that of said circuit, and a second switch means responsive to actuation of said sensitive relay for connecting said control relay directly to said power supply for actuating said control relay, said first switch means being responsive to actuation of said control relay to actuate said alarm element.

2. In a fire detection system of the character described, the combination of an electrical power supply, a balanced resistance circuit connected to said power supply, an alarm element in one arm of said circuit, an external alarm relay in said arm of said circuit, a thermo-responsive detection unit in an opposed arm of said circuit, a control relay in series with said balanced circuit, said balanced circuit depressing the current flow through said

control relay and said alarm element and said external alarm relay to an inoperative value, a normally-open external alarm circuit, switch means responsive to actuation of said external alarm relay for closing said external alarm circuit, means responsive to a condition of unbalance in said circuit for actuating said control relay, and switch means responsive to actuation of said control relay for actuating said alarm element and said external alarm relay.

3. In a fire detection system of the character described, the combination of an electrical power supply, a normally balanced Wheatstone bridge connected in series with said power supply, a thermo-responsive detection unit in one arm of said bridge, a directional relay connected across said bridge and energizable in response to a condition of unbalance in said bridge, a trouble alarm circuit, first switch means responsive to one direction of current flow through said relay for actuating said trouble alarm circuit, a normally-open fire alarm circuit, second switch means responsive to an opposite direction of current flow through said relay for establishing said fire alarm circuit, means for causing current flow in said one direction in response to a decrease in the electrical resistance of said thermo-responsive detection unit, means for causing current flow in said opposite direction in response to an increase in the electrical resistance of said thermo-responsive detection unit, means for reversing said current flow in said opposite direction in response to an infinite increase in the electrical resistance of said thermo-responsive detection unit, and means provided in said thermo-responsive detection for adding electrical resistance to said unit in response to a predetermined value of temperature.

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