

April 23, 1968

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3,380,045

REDUNDANT FIRE DETECTION CIRCUIT

Filed April 26, 1965

2 Sheets-Sheet 1

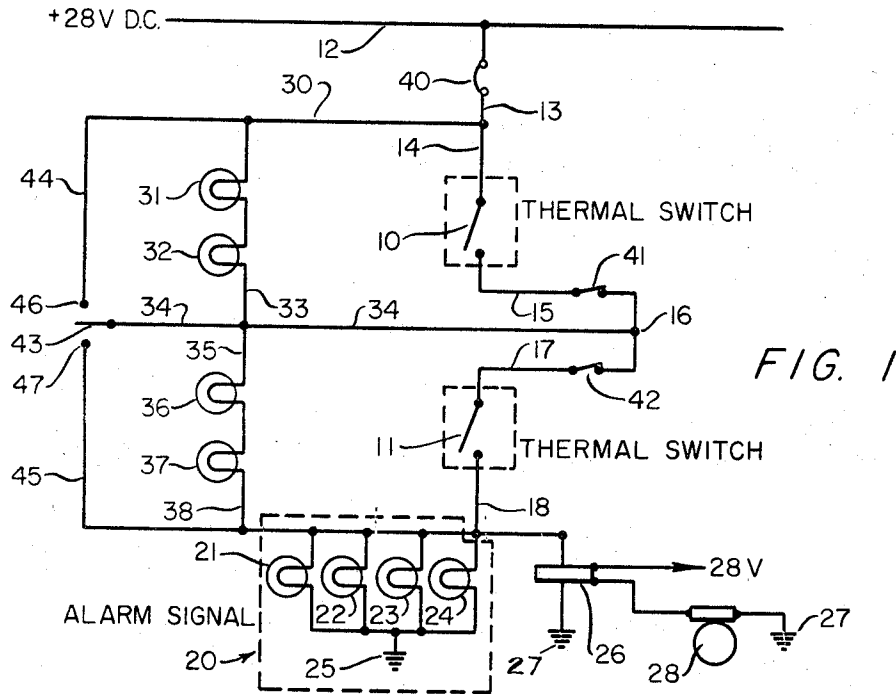


FIG. 1

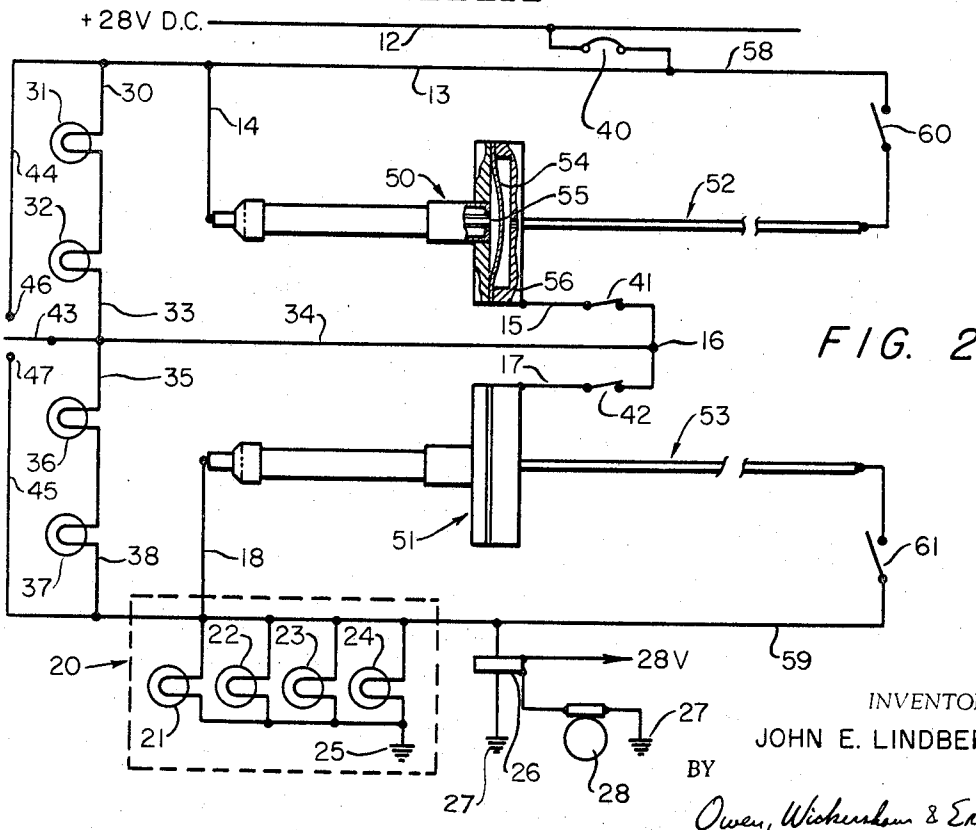


FIG. 2

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3,380,045
REDUNDANT FIRE DETECTION CIRCUIT
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 Filed Apr. 26, 1965, Ser. No. 450,645
 16 Claims. (Cl. 340-227)

ABSTRACT OF THE DISCLOSURE

This so-called "redundant-type" of fire detector circuit combines a source of power with two fire detector switches which are in series with each other and with the power source, and an alarm signal also in series with the fire detector switches. The alarm signal may comprise a parallel network of signal lamps with power return means on the opposite side of the network from the fire detector switches. A circuit breaker lies between the power source and the fire detector switches. A caution signal in parallel with each fire detector switch comprises a plurality of signal lamps in series having a higher total resistance than alarm network, so that one, but not both of the caution signals will light if only one of the fire detector switches is closed, while the alarm signal will light instead of the caution signal if both fire detector switches are closed. A low-resistance shunt path parallel to each fire-detector switch and to its caution signal has a normally open manually operable switch for closing the shunt path. Other test switches are also provided in preferred forms.

This invention relates to a fire-detection circuit providing superior protection against false warning and non-operativeness. The circuit is especially useful in aircraft fire-detection systems.

Most fire-detector circuits heretofore known have been plagued by factors that produced false warnings, and in aircraft the result was to subject the occupants to severe risks. In fact, conventional aircraft fire detectors (other than some shown in some of my patents and patent applications) have given, on the average, ten false warnings per true warning. An object of the present invention is to reduce markedly the number of false warnings that occur with conventional systems and to reduce to a minute probability the number of false warnings to be expected with the systems shown in my previous patents.

Another difficulty with many types of fire detection systems heretofore has been that parts have tended to get out of order, and it has often been difficult to determine whether the device was working properly, even with various test systems that have been available. Another object of the present invention is to introduce a superior system of testing the components to find out whether they are operative.

Heretofore, when an aircraft fire detection system was inoperative, the plane relying on it could not take off. A further object of the present invention is to provide a system in which certain types of inoperativeness will not necessitate holding the aircraft on the ground and still will not conflict with the safety requirements.

Aircraft manufacturers, by computer research and experience tables, have discovered that it is possible to reduce substantially the number of false warnings and the difficulties attendant upon failures within the system, whether they give false warnings or not, by providing what is known as a redundant electrical circuit. In other words, by providing two systems, the likelihood of disabling conditions occurring in both systems simultaneously is very low, much lower than for a single system. In fact, the use of a redundant circuit can reduce to a very small fraction the chances for failure or false warn-

ings, in comparison with a single system. Because of this and because of the bad experience of previous fire detection systems, some aircraft manufacturers require redundant circuits, and the present invention provides an improved redundant circuit.

A difficulty with redundant circuits heretofore in use has been that they have required a number of relays, at least twice as many as the single circuits. In a typical airplane, this would typically call for a dozen or more relays. Another object of the present invention is to enable the manufacturer to eliminate these relays and to provide a system which will give as good or better results without the use of relays, which are expensive and somewhat unreliable and have been another source of trouble.

Other objects and advantages of the invention will appear from the following description of some preferred forms.

In the drawings:

FIG. 1 is a circuit diagram of a redundant fire-detection circuit incorporating practically any type of thermal switch.

FIG. 2 is a similar circuit diagram particularly related to a circuit using a sensor and responder of the type shown in my previous patent applications.

FIG. 3 is a circuit diagram similar to FIG. 2, including an integrity test circuit.

FIG. 1 shows a simple redundant electrical circuit of this invention that can employ any suitable type of thermal switch, using two such switches 10 and 11 and in series with each other and with an alarm signal 20. Each of the switches 10 and 11 may be a spot point thermal switch or may be a continuous-type fire detector cable of the resistance type or may be another type of fire-detection device. While only one such installation is shown here, there may be a series of such installation. The two switches 10 and 11 are normally installed close enough together to give similar results and far enough apart so that phenomena causing damage to one would not ordinarily damage the other.

From a direct-current hot line 12, in aircraft typically of 28 volts, a takeoff line 13 leads via a lead 14 to the first detection switch 10. On the opposite side of the detection switch 10 a line 15 may lead to a junction 16, and the junction 16 may be connected by a line 17 to the second thermal switch 11. The other side of the switch 11 is connected by a line 18 to the alarm signal 20, which is made up of a plurality of lamps in parallel, preferably behind a red transparent cover, so that when they are lighted they give a red color. For example, the signal 20 may comprise four alarm lights 21, 22, 23, and 24, all of the same wattage, such as GE-327 bulbs of 28-volt and 0.04 amp rating. In some circumstances there may be more or fewer lights but in the 28-volt circuit using this kind of bulb, four is the preferable number, and the four lamps 21, 22, 23, and 24 are in parallel with each other and are grounded at a ground 25. There may also be an audible signal, such as a bell relay 26 through which the line 18 is connected to a ground 27 and which, when energized, rings a bell 28.

For normal operation, since the two switches 10 and 11 are subjected to substantially the same temperature conditions, either they will both be opened or they will both be closed. That is, so long as both are operating properly and neither they nor their circuits are subjected to a fault, then if there is a fire, both switches 10 and 11 will be closed due to the fire and they will light the alarm signal 20 and ring the bell 28. If there is no fire, then both switches 10 and 11 will normally be open, and no lights will be on, nor will the bell ring.

However, if either one of the two switches 10 or 11 is not working properly, a problem would be created in the circuit as so far described, since the two switches 10 and

11 are in series. Thus, if one switch 11 were to become grounded, then when the other switch 10 was closed by fire, the current from the line 13 would be grounded, and no alarm would be actuated; so the operator would not know that there was a fire. Or if one switch 10 were simply inoperative while the other switch 11 were still operative, their being in series would prevent any alarm being given in the circuit as so far described.

To enable indication of such faults and to make it possible for an aircraft to take off when one of the two switches 10 and 11 is operative, I provide some supplemental circuit elements. A line 30 leads from the line 13 through two lights 31 and 32 in series and a line 33 to a line 34, which is connected to the junction point 16. The line 34 is also connected by a line 35 through two further lights 35 and 37 and a line 38 to the alarm signal 20. The individual lamps 31, 32, 36, and 37 are preferably identical to the individual lamps 21, 22, 23, and 24, and are preferably located behind a transparent amber cover, to give a "caution" or amber signal when lighted. Note that they are in sets of two lamps in series in each instance rather than in parallel, as are the lamps 21, 22, 23, and 24. For different voltage-current requirements, it is possible to have more lights or fewer. In this arrangement, the lamps 31 and 32 are in parallel with the thermal switch 10 and the lamps 36 and 37 are in parallel with the thermal switch 11. The circuit values are chosen such that in normal operation the power supplied to the bypass circuit from line 13 through line 30 and the four caution lamps 31, 32, 36, and 37 in series to the four parallel lamps of the alarm signal 20 is insufficient to light any of the eight lamps involved; however, a circuit through the two thermal switches 10 and 11 will light the parallel network signal 20 and if either switch 10 or 11 is closed but the other switch 11 or 10 is open, then one pair of caution lights 31, 32 or 36, 37 will light while the alarm lights 21, 22, 23, and 24 will not light.

Thus, so long as all the switches and circuit are working properly, both switches 10 and 11 are either open or both of them are closed. When they are both open, no lamps are lighted, and when they are both closed, the bell 28 rings and the alarm signal 20 is lighted. However, if something is wrong, certain conditions will cause the caution lights 31 and 32 to come on, and certain other conditions will cause the caution lights 36 and 37 to come on, but never both sets at once. For example, if the lights 31 and 32 come on, this means that the circuit between the lamp 32 and the ground 25 or 27 is completed. This might mean that the switch 11 is being closed because of actual fire conditions, or it may mean that there is a short circuit across the switch 11, or it may mean that the switch 11 is grounded. In any event, something is wrong. Similarly, a lighting of the lamps 36 and 37 indicates that something is causing actuation or bypassing or grounding of the thermal switch 10, while the thermal switch 11 is not being actuated.

In the circuit as described so far, the results are ambiguous, because there is no way to tell which of the switches 10 and 11 is operating properly and whether the one which is closed is giving a false warning or a true warning. To aid in further determination, I provide additional circuit elements, including a circuit breaker 40 in the line 13, a normally-closed switch 41 in the line 15, and a normally-closed switch 42 in the line 17. I also provide a normally open switch 43 on the line 34 and leads 44 and 45 with normally open switch contacts 46 and 47. When the switch 43 is closed against the contact 46, the lead 44 is in parallel with the lamps 31 and 32 and short circuits them and also the thermal switch 10. When the switch 43 is closed against the contact 47, the lead 45 is in parallel with the lamps 36 and 37 and short-circuits them and also the thermal switch 11.

Let us now suppose that the lights 31 and 32 are lighted, showing that the switch 11 is either closed or short-circuited or grounded and that the switch 10 is open or

its circuit broken. We can tell which by opening the switch 41 and closing the switch 43 against the contact 46, for if the switch 11 is really closed, the lamps 31 and 32 will go out and the red alarm signal 20 will be lighted and the bell 28 will ring, giving the fire signal. Note that the opening of the switch 41 prevents the switch 10 from being considered in the circuit at all, takes it completely out, and also takes out any ground or fault that there might be in the wiring thereto. If in these circumstances, when the switch 43 is thrown against the contact 46, the alarm signal 20 does not come on and the bell 28 does not ring, the circuit is at fault; if the switch 11 is grounded, the circuit-breaker 40 will be opened. If all lights go out and the circuit breaker remains closed, then the switch 41 is closed again, and the circuit breaker 40 should then open, indicating a ground on the switch 41 side of the switch 10.

If there is a ground on the power side of the switch 10, then the circuit breaker 40 will open forthwith.

If the alarm lights 36 and 37 are the only ones lighted, then a test is made by closing the switch 43 against the contact 47. If the thermal switch 10 is closed by an actual fire, the alarm signal 20 will light and the bell 28 will ring. If they do not light, and the circuit breaker 40 pops open, there is a ground between the light 37 and the alarm signal 20, possibly on the low side of the switch 11.

If the tests show that the switch 10 cannot be relied on, but switch 11 can, then the switch 10 is removed from the circuit by closing the switch 43 against the contact 46, and opening the switch 41. If the switch 11 is not to be relied on but the switch 10 is all right, then the switch 43 is closed against the contact 47 and the switch 42 is opened.

A still better and more refined system is shown in FIG. 2. Where the elements are identical the same reference number still applies and re-description is unnecessary. Here the conventional thermal switch 10 is replaced by a gas-pressure operated fire detection responder 50 of my U.S. Patent 3,180,956 and the thermal switch 11 is replaced by a gas-pressure operated responder 51. The actuation for the responder 50 is provided by a sensor 52, and a sensor 53 actuates the responder 51. The sensors 52 and 53 are gas-pressure devices of the type disclosed in my U.S. Patent 3,177,479. They contain gas and possibly a material which releases additional gas when heated, so that when the metal sensor tube 52 is subjected to heat, the pressure inside increases to a point where at a predetermined pressure (attained at a predetermined temperature) a diaphragm 54 in the responder 50 will be closed against an electrode 55 and thereby connect the lead 14 to the lead 15 through the responder housing 56. The same thing happens inside the other sensor-responder combination 51, 53 when it is actuated. Since the metal sensor tube 52 is conductive, and since it is in this instance electrically connected to the responder housing 56, I provide a continuity test through the sensor 52 by means of a lead 58 and switch 60, and a similar lead 59 and switch 61 provide a continuity test for the sensor 53. The lead 58 is connected to the line 13, while the lead 59 is connected to the alarm devices 20 and 26. This gives still more information as to what is happening. Note also the important fact that the line 14 is connected to the electrode 55 of the responder 50, while it is the line 18 that is connected to the electrode of the responder 51, the lines 15 and 16 being connected to the respective housings.

In some uses the responder-sensor units 50, 52 and 51, 53 will be identical to each other, but in other uses it may be desirable to have them such that the responder 50 is actuated at a lower temperature than the responder 51. It is better to have the responder 50 which responds to the lower temperature located as the first in the series, i.e., closer to the power line 12, so that normally the higher-temperature responder 51 will not close unless the first responder 50 closes.

In the unit of FIG. 2, the engineer may check the system before the airplane takes off to see whether it is operating properly. He first closes the switch 60, in which event the lights 36 and 37 should become lighted. Then he releases the switch 60 and closes the switch 61, which should light the lights 31 and 32. Then he closes both switches 60 and 61, and the alarm signal 20 should then become lighted, and the bell 28 should ring. In this way he checks whether all the bulbs are working; at the same time he is simultaneously checking separately and together the continuity of the two fire detection systems. Thus, if at this time he should find that either the red lights or the yellow lights do not go on or that one set of yellow lights does not go on, he can check further by using the switch 43 to find out whether it is a fire detector device 50, 52 or 51, 53 which is inoperative or the lamps 31 and 32. If when he closes the switch 43 against the contact 47, the lamps 31 and 32 do not light, then it is the fault of one or the other of the two lamps 31, 32 and they should immediately be replaced. If on the other hand the lights 31 and 32 did not come on when he closed the switch 61 but do come on when the switch 43 is closed against the contact 47, then there is something wrong with the fire detection unit 51, 53. The unit 50, 52 is similarly tested.

With such testing out of the way, if the test shows that both fire detector units and all lights are working, then the plane is entitled to clearance on this point. It, however, either one of the two units does not work but one of them does work, then the cutoff switch 43 is closed to cut out that particular unit, and the appropriate switch 41 or 42 is also simultaneously left open, so that the complete inoperative unit is bypassed by the line 44 or 45, and reliance is then made on the single operative unit. Then, at the end of the flight the maintenance man is told to repair or replace the unit which did not work, so that it can be used at another time.

Now assume that the lights 31 and 32 come on during the flight with the switches 41 and 42 closed, as they are normally, and the switch 43 open, as it normally is, and both switches 60 and 61 open. In the instance where the first responder-sensor unit 50, 52 is an overheat detector operating at a lower temperature than the second unit 51, 53, this could not mean that the temperature is in the overheat range but not in the fire range, for in that event it would have been the lights 36 and 37 that would have been lighted. The operator knows that something is wrong in the system if the lights 31 and 32 come on, for the fire-detection device 51, 53 would seem to be showing that there is fire without overheating, which is an impossibility. To check, the operator first closes the switch 60. If the circuit is continuous, it will then send current through the sensor 52 but around the responder 50, and if the unit 51 is really closed, the red lights 20 will be lighted and the bell 28 will ring. If, on the other hand, there is a ground anywhere along the sensors 52 or 54 (which are normally insulated and shielded), or if the housing 56 of the responder 50 is grounded, then the circuit breaker 40 will immediately be thrown open, and the operator then knows that there is a ground. He can tell where the ground is, by first opening the switch 60, then opening the switch 41, then reclosing the circuit breaker 40, and then closing the switch 60 again. If the circuit breaker 40 is again thrown, this clearly shows that the ground is in between the switches 60 and 61. If, however, it is not there, then the lights 31 and 32 will remain lighted. The switch 43 can then be closed against the contact 46, and a ground will throw the circuit breaker 40. Note that if the ground came ahead of the switch 60, diaphragm 54, light 31, and switch contact 46, then no lights would be lighted but the circuit breaker 40 would be thrown, so this again helps to indicate the location of the fault. Thus the circuit breaker 40 is extensively used to detect the location of the fault.

If the test shows that the unit 51, 53 is operating prop-

erly, then the unit 50, 52 is cut out by throwing the switch 43 against the contact 46 and opening the switch 41. If the unit 51, 53 is bad, then the unit 51, 53 is similarly cut out, and the unit 50, 52 is relied upon.

If the lights 36 and 37 are the only ones that come on, this may indicate a true overheat warning, or an "overheat" which is really a fire with the unit 51, 53 inoperative, or a ground fault. Again the operator can test for which it is by first closing the switch 61 and seeing whether the bell 28 and signal 20 indicate that "overheat" was right. If they do not, then the switch 43 is closed against the contact 47 to see whether the red lights and bell come on (fire) or whether they do not and the circuit breaker 40 is thrown (ground).

Further refinements are desirable, including the shielding and safety device shown in my application Ser. No. 363,836 filed Apr. 30, 1964. Also, integrity testing by heating the sensors 52, 53 is desirable. Each may be separately heated by an independent power source, transformer coupled to the line leading to the distal end of the sensors 52, 53, this being done as described in my application Ser. No. 126,437 filed July 13, 1961. These refinements, being explained elsewhere, will not need further description here.

A still more refined integrity test system is shown in FIG. 3 where most of the parts remain the same as in FIG. 2. A test relay 62 is connected between the power line 12 and the line 34 by a line 63 and has a normally open, manual switch 64. The test relay has two normally open switches 65 and 66 each connected to grounds 67 and 68 respectively. A load-carrying resistor 69 is in parallel with the relay 62, and a separate circuit breaker 70 is preferably employed. The bell relay 26 is here shown as having a normally open bell operating switch 26a and also having two normally closed switches 71 and 72 which are opened when the bell relay 26 is energized. The sensor tube 52 is connected through the switch 71 and the test relay switch 65 to ground 67 when both the switches 71 and 65 are closed. The sensor 53 is connected to the ground 68 when both the bell relay switch 72 and the test relay switch 66 are closed.

To use the circuit of FIG. 3 in integrity testing, the switch 64 is manually closed energizing the test relay 62 and closing the test relay switches 65 and 66. Power then passes from the power line 12 by the line 63, switch 64, test relay 62, and line 34, to the junction 16. From there one branch goes through the switch 41, lead 15, responder housing 56, sensor tube 52, bell relay switch 71 and test relay switch 65 to the ground 67. The sensor housing 52 then becomes a resistance heater and heats the sensor to the point where actual operation of the responder 50 is caused by closing the diaphragm 54 against the electrode 55. If the first detector device 50, 52 is operative, this heating will cause its operation. Similarly, the sensor 51, 53 is heated and caused to operate at the same time, with the result that the alarm signal 20 is lighted and the bell relay 26 is energized. Energization of the bell relay 26 closes the relay switch 26a and rings the bell 28. It also opens the switches 71 and 72 to prevent further heating of the sensor tubes 52 and 53. The test relay 62 may be a holding relay which is opened by energization of the relay 26, or the relay 26 may be a holding relay, or the switch 64 may be a spring switch which the operator holds closed until he sees that the devices are operating properly. By opening the switch 41 the device 51, 53 can be individually tested, and by closing the switch 41 and opening the switch 42 the device 50, 52 can be tested individually.

While the circuits illustrated in the drawings have been grounded circuits, the grounds may be replaced by lead wires to provide an above-ground D.C. or A.C. circuit.

While the lamps 21, 22, 23, 24, 31, 32, 36 and 37 have been shown in the parallel and series relationship described, only one lamp need be in each signal, so long as the proper impedance values are chosen, and in each

signal resistors or other impedance devices may be substituted in the circuit as shown for all but one lamp. However, the use of identical lamps as shown has several advantages: standard identical parts are convenient and easily obtainable and easily replaced, the resistance-load increase in lamps is rapid as the rated load is approached (the resistance at full load is ten to twenty times as much as the no-load resistance), and all energy is utilized to make light that performs the alarm function. There is also increased integrity in the device 20 due to redundancy of lights. Note also, that even if the lamps 31, 32, 36, and 37 all burn out, operative fire detector switches will still cause the alarm to be given; so the presence of the lamps 31, 32, 36 and 37 does not adversely affect reliability in any event.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. A redundant type fire detector circuit, including in combination:

- a source of power,
- two fire detector switches in series with each other and with said power source,
- an alarm signal in series with said fire detector switches on the opposite side from said power source, said alarm signal comprising a parallel network of signal lamps with power return means on the opposite side of said network from said fire detector switches,
- a circuit breaker between said power source and said fire detector switches,
- a caution signal in parallel with each said fire detector switch, each caution signal comprising a plurality of signal lamps in series and having a higher resistance than said network so that one but not both caution signals will light if only one of said fire detector switches is closed, while said alarm signal will light instead if both said fire detector switches are closed, and
- a low resistance shunt path parallel to each said fire detector switch and to its said caution signal having a normally open manually operable switch for closing said shunt path.

2. The circuit of claim 1 having between each said shunt switch and its said fire detector switch a separate normally closed switch.

3. The circuit of claim 1 wherein each said fire detector switch comprises a gas-pressure type sensor with a conductive closed sensor tube and a gas-pressure operated responder having a conductive housing, a conductive electrode insulated from said housing, and a diaphragm electrically connected to said housing and normally apart from said electrode and actuatable to a position against said electrode, the responder closer to said power source having its said electrode connected to said power source through said circuit breaker, while the other responder has its said electrode connected to said alarm signal.

4. The circuit of claim 3 wherein each said conductive sensor tube is electrically connected at one end to said responder housing and wherein there is a continuity test circuit connected to the opposite end of said sensor tube, having a normally open switch connected in parallel with said electrode.

5. A redundant type fire detector circuit, including in combination:

- a series circuit, comprising in order, a source of D.C. power, a circuit breaker, two fire detector switches in series with each other, an alarm signal, and a ground, said alarm signal comprising a parallel network of signal lamps,

a pair of caution signals, one in parallel with each said fire detector switch, each caution signal comprising a plurality of signal lamps in series and having a higher resistance than said network so that one but not both caution signal will light if only one of said fire detector switches is closed, while said alarm signal will light if both said fire detector switches are closed,

a pair of low resistance shunt paths, one in parallel with each said fire detector switch and with its said caution signal and

a normally open manually operable switch for closing each said shunt path.

6. The circuit of claim 5 wherein all said signal lamps are identical in their wattage.

7. A redundant type fire detector circuit, including in combination:

- a series circuit including sequentially a source of power, a circuit breaker, two fire detector switches in series with each other, an alarm signal, and a ground, said alarm signal comprising a parallel network of identical signal lamps,

each said fire detector switch comprising a gas-pressure type sensor with a conductive closed gas-containing tube and a gas-pressure operated responder connected to said sensor and having a conductive housing, a conductive electrode insulated from said housing, and a diaphragm electrically connected to said housing and normally apart from said electrode and actuatable to a position against said electrode, the responder closer to said power source having its said electrode connected to said power source through said circuit breaker, while the other said responder has its said electrode connected to said alarm signal,

a caution signal in parallel with each said fire detector switch, each caution signal comprising a plurality of signal lamps in series, each said signal lamp being identical to that in said network, whereby one caution signal only will light if only one of said fire detector switches is closed, the caution signal lighted being the one other than the one in parallel with the closed fire detector switch, while said alarm signal will light if both said fire detector switches are closed,

a low resistance shunt path parallel to each said fire detector switch and to its said caution signal, and a normally open manually operable switch for closing each said shunt path.

8. The circuit of claim 7 having between each said shunt switch and each said conductive housing a separate normally closed switch.

9. The circuit of claim 8 wherein each said conductive sensor tube is electrically connected at one end to said responder housing and wherein there is a continuity test circuit connected to the opposite end of said sensor tube, said test circuit having a normally open switch connected in parallel with said electrode.

10. The circuit of claim 7 wherein there is a manually energizable electrical test relay in series with said source of power and with that end of each said conductive tube which is connected to said responder, said relay having normally open switch means between the other end of each said tube and ground, for integrity testing of said fire detector switches.

11. The circuit of claim 10 wherein said alarm signal includes a bell-actuating relay and a bell, said relay having normally closed switches in series with said tube and said normally open switch means controlled by said test relay, said normally closed switches of said bell-actuating relay being opened when said bell-actuating relay is energized.

12. A redundant type fire detector circuit, including in combination:

- a source of power,
- two fire detector switches in series with each other and with said power source,
- an alarm signal in series with said fire detector switches on the opposite side from said power source with

- power return means on the opposite side from said fire detector switches,
- a circuit breaker between said power source and said fire detector switches,
- a caution signal in parallel with each said fire detector switch, each said caution signal having a higher resistance than said alarm signal such that one but not both caution signals will light if only one of said fire detector switches is closed, while said alarm signal will light instead if both said fire detector switches are closed, and
- a low resistance shunt path parallel to each said fire detector switch and to its said caution signal having a normally open manually operable switch for closing said shunt path.
13. A redundant type fire detector circuit, including in combination:
- a source of power,
- two fire detector switches in series with each other and with said power source,
- an alarm signal in series with said fire detector switches on the opposite side from said power source, with power return means on the opposite side from said fire detector switches.
- a caution signal in parallel with each said fire detector switch, each said caution signal having a higher resistance than said alarm signal such that one but not both caution signals will light if only one of said fire detector switches is closed, while said alarm signal will light instead if both said fire detector switches are closed.
14. A redundant type fire detector circuit, including in combination:
- a series circuit including sequentially a source of power, two fire detector switches in series with each other, an alarm signal, and a ground,

- each said fire detector switch comprising a gas-pressure type sensor with a closed gas-containing electrically conductive tube and a gas-pressure operated responder connected to said sensor and having a normally-open pressure actuated switch,
- a caution signal in parallel with each said fire detector switch, each caution signal having a higher impedance than said alarm signal such that one caution signal only will light if only one of said fire detector switches is closed, the caution signal lighted being the one other than the one in parallel with the closed fire detector switch, while said alarm signal will light if both said fire detector switches are closed.
15. The circuit of claim 14 wherein there is a manually energizable electrical test relay in series with said source of power and with that end of each said conductive tube which is connected to said responder, said relay having normally open switch means between the other end of each said tube and ground; for integrity testing of said fire detector switches.
16. The circuit of claim 15 wherein said alarm signal includes a bell-actuating relay and a bell, said relay having normally closed switches in series with said tube and said normally open switch means controlled by said test relay, said normally closed switches of said bell-actuating relay being opened when said bell-actuating relay is energized.

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