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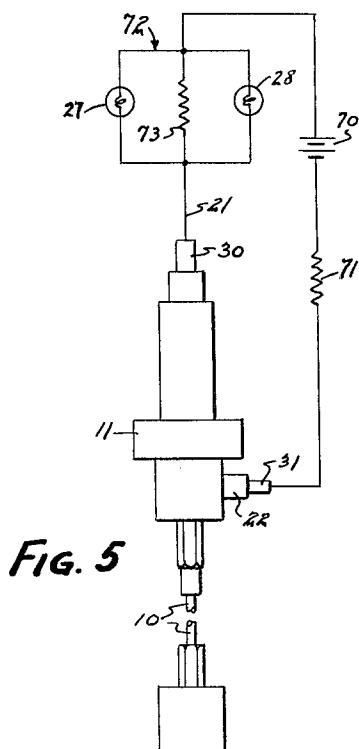
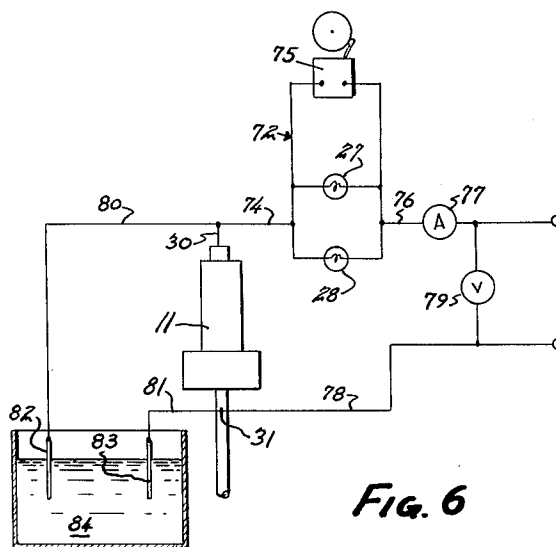
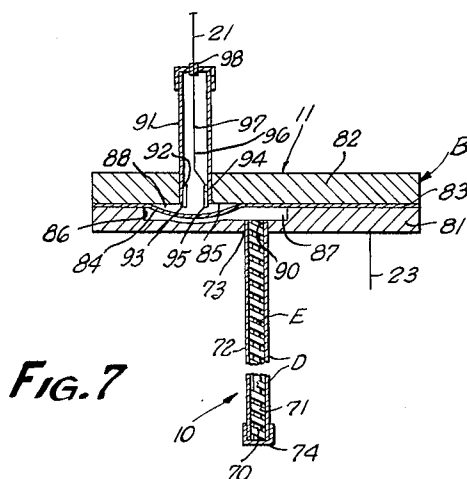
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3,154,772

PREVENTION OF FALSE WARNING

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3 Sheets-Sheet 3



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3,154,772
PREVENTION OF FALSE WARNING
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9 Claims. (Cl. 340—229)

This invention relates to improvements in warning or alarm circuits. More particularly it relates to improvements in circuits used for detection of fires in airplanes and elsewhere. This application is a continuation-in-part of application Serial No. 50,228, filed August 17, 1960, now abandoned and of application Serial No. 815,406, filed May 25, 1959, now Patent Number 3,122,728, issued February 25, 1964.

Fire detection circuits and some other types of warning circuits heretofore in use have been prone to give false alarms. Recent statistics indicate, for example, that on the commercial airlines in the United States alone there are, on the average, two false fire warnings every day. Each false warning is liable to cause a fatal crash, and several of these have occurred each year in recent years. Even when the plane and passengers are saved, each false fire warning requires immediate remedial action, such as dumping excess fuel down to the allowable landing weight and landing as soon as possible, and the resultant disruption of the schedule, the cost of landing, taking off, and obtaining clearances, and other expenses resulting from this false warning have been estimated to average more than \$20,000 additional expenditure per false fire warning.

One object of the present invention is to provide a fire detection circuit that will not give such false fire warnings.

A leading cause of the false warnings in fire detection systems has been the presence of moisture or electrolytic solutions (some of which are formed merely by condensation or atmospheric moisture coming into contact with fire detector systems using salts or having soluble salt deposits on their surfaces), and it is to this particular cause of false warnings that the present invention is directed. With this invention it becomes possible to completely eliminate this factor as a cause of false alarms. The invention obtains such favorable results that the entire electrical system can even be immersed in an electrolyte such as salt water, even with terminals intentionally exposed, and yet there will be no false fire warning. Moreover, the system will still give a true warning when there is fire.

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

In the drawings:

FIG. 1 is a diagrammatic view of a fire detection circuit embodying the principles of the invention. In this circuit the heat sensor has been broken in the middle to conserve space, the sensor often being 40 feet long or longer.

FIG. 2 is a diagram of a modified form of circuit employing a series of spot-type heat detectors.

FIG. 3 is a graph illustrating the time delay and threshold power conditions affecting operation of an indicator lamp used in the system.

FIG. 4 is a graph illustrating the difference between large currents and small currents in effecting electrode-to-electrode resistance.

FIG. 5 is a diagrammatic view of another modified form of circuit embodying the principles of the invention.

FIG. 6 is a diagrammatic view of a test arrangement used to obtain some test data.

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FIG. 7 is a somewhat diagrammatic view in elevation and in section of a responder and sensor of the type that may be used in the system of FIG. 1.

I have found that false fire warnings can be prevented in many types of alarm circuits, at least where the false warning is due to shorting through moisture or electrolyte, by proper choice of circuit components. More particularly, I provide a relatively large-current, low-voltage flow at the actuator means or responder to passivate the electrodes (i.e., coat them with a resistive coating) across which the shorting might take place and to do so quickly, before there is sufficient power on the warning indicator to give an alarm. It may not be at once apparent why this system works; so rather than trying to explain it in vacuo, it will probably be clearer to first describe a typical system employing the invention and then to explain how this system prevents false alarms.

Accordingly, considering FIG. 1 first, a novel circuit is shown based on the use of a fire detection sensor and responder of the type described and claimed in my co-pending application, Serial No. 815,406, filed May 25, 1959. For those not acquainted with that application, it may be said that a sensor 10 contains a gas-emitting material that when heated increases the pressure inside the sensor and transmits the pressure to a responder 11, a type of pressure switch that, when actuated, closes the circuit. When the responder switch 11 is open, I preferably provide a standby testing resistance 12 (which may be inside the responder) of about 8 ohms, for a test use that will be explained soon. When the switch 11 is closed, however, the resistance across the responder drops to approximately zero. In other words, the switch 11 is fully closed when the sensor 10 actuates it. The sensor 10 is not electric in its function, and therefore the actuation of the responder 11 does not depend upon any electric circuit. The sensor 10 is thus non-electric, and the switch 11 which is tripped then actuates certain devices in the electric circuit outside the sensor to give warning. Such a circuit is shown in FIG. 1.

FIG. 7 shows a preferred form of transducing agent E enclosed in a sensor tube D. Here the transducing agent E is a filament 70, such as zirconium wire, and may be about 0.025" to 0.050" in diameter, for example. A ribbon 71 of suitable material, such as molybdenum, preferably about 0.020" wide and 0.002" thick, is wrapped tightly around the filamentary transducing agent 70 and fits snugly within the tube D. The ribbon 71 physically spaces the filament 70 from the walls 72 of the tube D and prevents the transducing agent 70 from fusing or welding to the tube walls 72, even in the event that the sensor A is exposed to extreme heat. As a simplified example of installation of the sensor 10 to the responder 11, one end 73 (FIG. 7) of the tube D may be connected by a gas-tight seal to the responder B, while the other end 74 of the tube D is still open. This free end 74 may be connected to a vacuum pump and the tube D pumped free of gas. Then the tube D is heated, and then pure hydrogen is forced in through the free end 74, the zirconium filament 70 absorbing the hydrogen while it cools. The free end 74 is then sealed off, and the device is ready for operation.

FIG. 7 shows a simple form of responder B. The responder 11 has two circular plates 81 and 82, preferably of non-porous metal, between which is bonded (as by brazing) a thin metal flexible disc or diaphragm 83. The plates 81 and 82 are hermetically sealed together and are in electrical contact for their full peripheries and over a substantial margin, but in the center the diaphragm 83 has a spherical depression 84 called a "blister," which is free to move relative to the plates 81 and 82 and constitutes the active or movable part of the diaphragm 83. Use of a diaphragm with a blister 84 makes possible

the use of an upper plate 82 with a planar lower surface 85 and gives a more predictable response, but other diaphragm structures may be used where feasible. The lower plate 81 is formed with a recess 86 in its upper surface, and the diaphragm 83 divides the resultant cavity between the plates into two regions or chambers 87 and 88. Since the lower region 87 communicates with the sensor 10, it may be called the "sensor chamber." The other region 88 is located on the opposite side of the diaphragm 83 from the sensor 10; so it may be called the "anti-sensor chamber." Of course, either plate 81 or 82 may actually be made by brazing together several thin plates of the desired configuration, and the recess 86 may be provided by using a stack of preformed thin washers over a disc. A preferred material for all the metal elements in the responder 80 is molybdenum. The end 73 of the sensor tube D is joined to and sealed to the lower plate 81, fitting within a hole 90. The region 87 is closed and sealed except for its communication with the lumen of the sensor tube D; so the inside of the sensor A and the sensor chamber 87 enjoy a common atmosphere to the exclusion of any other.

A tube 91 of non-porous ceramic material or other non-porous electrically-insulating material extends through an opening 92 in the upper plate 82 and is hermetically sealed in place there with its lower end 93 flush with the bottom surface 85 of the plate 82. The hole 92 and tube 91 are preferably centered with respect to the blister 84, on the anti-sensor side thereof. A metal electrode 94 is located inside and joined securely to the tube 91 at the end 93 nearest the blister 84, with a portion 95 of the electrode 94 extending below the lower surface 85 of the plate 82. The amount by which the portion 95 extends below the surface 85 is carefully controlled so as to be uniform in each responder of any particular design. This geometry means that the blister 84 can make electrical contact with the electrode portion 95 when the blister 84 is forced up by pressure in the sensor chamber 87. As shown, the electrode 94 may be annular to give good uniform contact with the blister 84 at that time and also to afford communication between the chamber 88 and the inside 96 of the tube 91. A conducting wire 97 extends from the electrode 94, preferably along the axis of the tube 91 and is brought out of the tube 91 through a hermetic seal at a sealing cap 98. The tube interior 96 and the anti-sensor chamber 88 thus enjoy a common atmosphere to the exclusion of any other.

If sufficient pressure is applied to the sensor side of the blister 84, it will deflect and make contact with the electrode portion 95, and if the deflecting force is removed, the restoring force of the blister 84 will return it to its relaxed position and thus break contact with the electrode portion 95. The force necessary to do this may be chosen by proper design of the blister to accommodate a wide range of values.

In the circuit a typical source of voltage, such as 115 volts-400 cycle current is applied through a transformer primary 15. A transformer secondary 16 has an output of about 3 volts at about one ampere. Current from the secondary 16 passes through the line 17, a manual switch 18, a lead 19, and a warning means 20 to a lead 21 that is connected to a terminal 30 of the responder switch 11 and to the standby resistor 12. A return circuit connects a terminal 31 on a body portion 22, to which the standby resistance 12 is also connected, through a lead 23, a switch 24 and leads 25 and 26 back to the secondary 16. The warning device 20 may comprise a pair of lamps 27 and 28 in parallel. These may be G.E. No. 43 lamps rated at 2½ volts at ½ ampere current, so that the two together will draw about one ampere. For greater lamp life and even lower circuit impedance the lamps 27 and 28 are preferably operated at about 2 volts and 0.45 ampere. This also increases the time it takes to heat the lamp filaments to incandescence. The

voltage applied here is purposely low to delay operation, and the resistance of two lamps in parallel is about 2 ohms. Except when there is a fire, the standby resistance 12 is not so low as to cause actuation of the warning device 20, for the 8-ohm resistance in this resistor is substantially greater than the resistance of the other circuit elements. Thus, the total resistance of the leads from the secondary 16 to the responder 11 plus the resistance of the leads from the responder 11 by the return line back to the secondary 16 total only about 1½ ohms maximum. The parallel resistance of the lamps 27 and 28

$$\left(R = \frac{E}{I} = \frac{2}{0.9}\right)$$

is about 2.2 ohms when the lamps are lighted and is about 0.5 ohm in standby condition, due to the very large change in the resistance of the tungsten filaments due to the change in temperature of the filaments. Thus, the total circuit resistance in this illustrative example is 1.5 ohms plus 0.5 ohm plus 8 ohms, during standby conditions, or a total of 10 ohms. This means a standby current of only about 0.32 ampere, with a 3.2 volt potential applied across the secondary 16, which current is well below the 0.6 ampere threshold operating current of the parallel lamps 27 and 28. However, when the sensor 10 is actuated by fire to close the switch 11, the substantially zero resistance between the terminal 30 and the terminal 31 bypasses the resistor 12, so that the total circuit external resistance is only 1.5 ohms, plus the 2.2 ohms lamp resistance, and the current then becomes 0.9 ampere, and the lamps 27 and 28 are lighted.

Now let it be supposed that the circuit so far described is immersed in salt water. What will happen? There will be a tendency for the circuit to short across between the terminal 30 and the terminal 31 through the salt water. One way in which this invention acts to make this short unlikely is to put the terminals 30 and 31 as far apart as possible, so that they are on opposite ends of the responder. This spacing alone has a good effect, but it is not the primary feature of the invention. Another valuable contribution of this invention is the elimination of all voids—exposing critical terminals rather than enclosing them, in hollow plugs where moisture, condensation, and salts tend to collect and cause trouble. But, while important, this elimination of voids is not the primary feature of the invention.

The primary feature is that the circuit components having the values already stated are such that the current passing between the terminals 30 and 31 through the electrolyte will quickly passivate the electrodes 30 and 31. It may achieve this passivation on some metals principally by building up a high-resistance oxide or salt coating on them, and by keeping the current high enough and the voltage low enough, this coating will build up very fast and cannot be broken down by the low voltage. The use of high voltages should be discouraged because high voltage tends to break down these coatings, in effect arcing through them. Passivation may result on other metals from a film of gas, or there may be both gas films and coatings.

Low currents have to be avoided, and this is one place where the prior art has apparently been unaware of the trouble caused by the use of low-amperage systems. The significance of this feature is somewhat explained by FIG. 4, which graphs the time in seconds against the electrode-to-electrode resistance built up by the electrode coating and gasification, if any. With a one-ampere current the curve F is very steep, and the coating is built up to a current-blocking value in a fraction of a second. With a one-milliampere current the curve E is very flat, and it may take hours or even days for sufficient coating to be built up to prevent the passage of current, even though the voltage drop at that point may be relatively low.

Now it is well known that electric light bulbs such as are used as the warning lamps 27 and 28 require, first, a certain minimum current (threshold current, see line A in FIG. 3) to give any light, regardless of time. This may be 0.6 ampere for the lamps 27 and 28 in this example. Second, above this threshold current A, it takes a finite time depending on the current value (see line B in FIG. 3) in order to build up enough heat to glow. A typical curve C in FIG. 3 shows what happens when the lamps operate. I have found that by the proper choice of currents and voltages in the circuit, made possible by proper choice of low-resistance circuit components, it is possible to prevent the warning lamps 27 and 28 from ever being lighted by a short-circuit between the terminals 30 and 31 through an electrolyte.

This invention uses circuit components that are relatively low in resistance and feeds to this low-resistance circuit a low voltage, in the nature of 1 to 6 volts, for example, at a current in the order of one ampere. The large current across the short acts very quickly (see curve F in FIG. 4) to build up the oxide, salt, or gas coating on the electrodes 30 and 31 to a resistance value D (FIG. 4) which the low voltage cannot break down. Meanwhile, as the current tries to build up heat in the lamps 27 and 28, the time factor is running, and as some coating is built up on the electrodes 30 and 31, the power transmitted to the lamps 27 and 28 drops, as shown in curve G in FIG. 3. As the power drops, it becomes harder than ever to heat the lamp bulbs 27 and 28, thereby slowing down the normal actuation time. It will be found that by using the circuit values that I have given, the passivation of the electrodes will be fully completed before the lamps 27 and 28 ever light and that as a result of the coating, they will never light.

In actual tests, I have taken clips of stainless steel wire and fastened them to the electrodes 30 and 31, immersed the wires in salt solution, and then moved them until they actually touched each other, and no short circuit occurred, because they were insulated by their coating or film. By vigorously rubbing them against each other to break the insulating film a false warning could be produced, but this is the only way that I have been able to obtain such a false warning. Of course, in actual installations there will be no way of rubbing the electrodes 30 and 31 against each other or of doing anything equivalent, short of purposeful sabotage.

The fact that the circuit is submerged does not prevent its operation, for if the sensor 10, which is not part of the circuit anyway, is exposed to a fire temperature and elaborates gas, the switch 11 will be closed and the lamps 27 and 28 will be lighted, as before.

To provide even greater safeguards for circuit integrity, I have also provided ways of testing whether the circuit elements are grounded, for it will be evident from the above description that if a *dead short* contacting ground could be obtained simultaneously between both the line 21 and ground and the line 23 and ground, it might be possible to obtain a false warning not due to exterior conditions. For testing purposes I connect a line 32 to the line 19, send it through a suitable ammeter 33, if desired, to a contact 34 of a switch 35. A return line 36 runs from a contact 37 to the line 26 and then to the secondary 16. A switch arm 38 may be placed against one of the contacts 34 or 37, and when that is done, a part of the circuit will be grounded through a ground 39. Thus, it is possible to ground either the low or high side of the circuit by using the switch 35.

This means that if the high side has in some way become grounded, this can be tested for by purposely grounding the low side of the circuit by means of the switch 35, in which case the lamps 27 and 28 will light, showing that the high side of the circuit is grounded.

Yet the mere grounding of the high side of the circuit itself would not have produced any false warning.

Similarly, if the low side of the circuit has been ground-

ed, it is tested for by moving the switch arm 38 against the contact 34 to purposely ground the high side of the circuit. Then, if the low side has been grounded, there will be an indication of this fact by a deflection of the needle of the ammeter 33; the amount of such deflection, when the ammeter 33 is properly calibrated, can show the location of the low-side ground, and remedial action can be taken. Yet, again, the grounding of either side of the circuit will not prevent actuation and *will not* change the operating point, nor the response rate, nor will it give a false alarm.

I provide a further check on the sensor apparatus by providing a sensor junction 40 which is connected by line 41, resistance 42, and line 43 to a switch contact 44. A switch arm 45 may be moved to connect the contact 44 to a contact 46, which, in turn, is connected to the high voltage terminal 15 by a line 47. Thus I can put through the high power to pass it through the sensor, and unless the sensor 10 itself is broken the lamps 27 and 28 will light.

The switches 18, 24 and 45 are ganged together and are shown in their normal position, that occupied during use of the device. In a second position, the switch 18 is in contact with a terminal 48 and the switch 24 is in contact with a terminal 49. This sends about 10 volts through the system, using the additional secondary 49a. This value of voltage is sufficient to light the lamps 27 and 28 even though passing through the 8-ohm resistor 12. Thus, it tests the integrity of the main circuit and gives assurance that if there is a fire, the circuit will work.

In the third position, the switch 18 is grounded and the switch 45 joins the terminals 44 and 46, thereby sending the 115-volt line voltage through the sensor 10. This tests whether the sensor 10 is intact, i.e., not severed. The resistance 42 is set at a value that will give about one ampere of current through the circuit at this time.

A modification of the system is shown in FIG. 2, in which a more conventional type of spot-point fire detector is used. (This brings up the point that even in the FIG. 1 system the type of actuator used is not critical. Any temperature-resistive pressure-switch actuator may be used.) In this instance there is again a transformer primary 50, and a secondary 51 connected by a line 52 to a warning device 53, again consisting of two lamps 54 and 55 of the same kind as described before. These lamps are connected to a line 56 to which a series of spot-point fire detectors or thermal switches 60, 61, 62 and 63 are connected. The positive side of these switches may be grounded through line 64 and ground 65 or alternately there may be a return line 66 connected to the line 64. Here, again, each of the thermal switches 60, 61, 62 and 63 is normally open, and there may be, if desired, a standby bypass resistance 67 for testing the circuit, as by raising the voltage at the primary 50. When the switches are all open, the warning device will not be actuated and when any of them is closed, the warning device 53 will be actuated. False warnings are prevented by holding the resistance of the leads of the circuit down to about 1.5 ohms and by using voltage and current values which result in passivation of the electrodes of the thermal switches 60, 61, 62 and 63 or any exposed wires to these electrodes before the lamps 54 and 55 can light. The voltages and currents may be, for example, a 5-volt (transformer secondary) system with about two volts across and about one ampere through the lamp circuit 53 when any one or more of the terminals of the switches 60, 61, 62 or 63 are closed. Even though these thermal switches may have their electrodes closer to each other than the switch 11 shown in the preferred form in FIG. 1, still, with these circuit values, the electrodes are passivated before the lamps can be lighted, and the lamps will therefore never be lighted. Of course, many other types of circuits could be shown but the principle has been explained. The problem is simply to balance (1)

the current at the place where the current could be shorted across the warning actuator with (2) the voltage at that same point and with (3) the power requirements of the working device.

FIG. 5 shows another circuit embodying the principles of the invention. Like that of FIG. 1, it has a sensor 10 and responder 11. However, no test circuit is here shown and there is no bypass resistor 12. After all, the test circuit is a good idea but it is no aid in avoiding false warnings; so I show this circuit in order that no one get the impression that there has to be a bypass resistor 12 or 67 or that there has to be a test circuit.

Furthermore, the FIG. 5 circuit employs D.-C. current, using a battery 70 to supply less than about seven volts, typically 2.5 to 3.2 volts, though it may be a six-volt battery, if desired. A resistance 71 is shown but is not actually a circuit element merely representing the external resistances of the circuit except that of the warning device 72, which here—purely as an example—includes not only the lamps 27 and 28 but also a 2.5 ohm resistor 73. The resistor 73 may be a bell or a third lamp. In this circuit, there is a current of about 1½ amperes and about a two-volt drop through the warning device 72.

Here, too, the members 30 and 31 can be immersed in pure water or salty water without giving a false warning, for the pure water will not conduct enough current to actuate the warning device 72, while water salty enough to conduct current will passivate the electrodes 30 and 31 or even their lead wires if they are immersed. Of course, it is understood that I do not recommend unduly exposing the electrodes or their wires or any carelessness enabling them to get close together, but the invention will, in many if not most instances, prevent false warnings in spite of such carelessness.

In general, the greater the distance between the electrodes 30 and 31, the less chance there is for a short circuit between them creating a false warning, and that is why I prefer to keep them at a distance, even though the invention does not always require it. Similarly, the smaller the area of the electrodes, the less chance there is for a false warning, partly because the small areas can be passivated more quickly. Also, the area of the electrodes should preferably be small relative to the distance between them; in other words, the ratio of the area to the distance should be kept small.

FIG. 6 shows a somewhat different circuit arrangement used to obtain some test data reported herein as to the effect of using different kinds of metals, immersing them in different types and concentrations of electrolytes, and using different voltages. Here a responder 11, with electrodes 30 and 31 was connected by a line 74 to a warning device 72 comprising two lamps 27 and 28 and a bell 75. The device 72 was connected by a line 76 through an ammeter 77 to 60 cycle A.-C. house current through a Variac to give a regulated voltage. The electrode 31 was connected to the Variac by a line 78, and a voltmeter 79 was connected across the lines 76 and 78. Lines 80 and 81 were clipped to the electrodes 30 and 31 and terminals 82 and 83 at their ends were immersed in a bath 84.

For one series of tests, the bath 84 consisted of Berkeley, California, tap water. The distance between the terminals 82 and 83 was 0.05" and all the terminals were one square inch in area—far larger than the areas of the electrodes 30 and 31—except that of molybdenum which was one-half square inch. No change was detected in the surface of the terminals 82 and 83 as a result of any of this group of tests. Terminals of each of stainless steel, nioro (65% gold, 35% nickel), zinc, iron, brass, aluminum, platinum, nickel, molybdenum, titanium, zirconium, tantalum, copper, and coin silver were each tested at the 0.05" distance apart—far closer than the distances between the terminals 30 and 31, and not once was the warning device 72 or any part of it actuated at 3.2 volts A.-C. or D.-C. or at 10 volts A.-C. or D.-C.

In a second series of tests, the bath 84 was of a saturated water solution of sodium chloride at room temperature. Various areas of terminals, various distances between terminals, various metals, and several voltages, all as before obtained from the house current by a Variac, were tried, as shown in Table I. In all instances shown in this table, there was no actuation of the warning device, although, such activation could, in some instances, be obtained by using higher voltages or shorter distances between terminals or larger terminals.

Table I

Metal of terminals	Distance between terminals, inch	Area of terminals, square inches	Voltage
Nioro	.05	1	6 D.C.
Stainless steel	.05	1	3.2 D.C.
Zinc	Touch	1	2.5 D.C.
Do	1/32	1/4	6.2 D.C.
Iron	Touch	1	6.5 D.C.
Brass	Do	1	2.5 D.C.
Do	1/4	1	10 D.C.
Aluminum	Touch	1	3.3 D.C.
Do	1/32	1/4	7 D.C.
Platinum	Almost touch	1/4	7.5 D.C.
Nickel	.05	1	3.2 D.C.
Do	1/16	1/4	10 D.C.
Molybdenum	1/16	1/4	3.2 D.C.
Do	Touch	1/4	3.2 D.C.
Titanium	.05	1/4	3.2 D.C.
Zirconium	Touch	1/4	3.5 D.C.
Tantalum	.001	1/4	4.2 D.C.
Do	.05	1/4	10 D.C.
Copper	.001	1/4	3.8 D.C.
Nioro	1/8	1/8	6 A.C.
Stainless steel	1/16	1/4	4 A.C.

Coatings tended to form and were visible on nioro, molybdenum, titanium, and copper at the lower voltages. Otherwise, the metals appeared to be clean. The samples were then allowed to dry overnight, and all of the samples were then observed to be coated. Then the following touch tests were run dry (the terminals 82 and 83 were touched, and sometimes even rubbed, with the areas and A.-C. voltages noted), all without actuation of the warning device:

Table II

Metal	Area	Volts
Nioro	3/4	3
Do	3/4	10
Zinc	3/4	3
Iron	1	3
Do	1	10
Brass	3/4	3
Aluminum	3/4	3.2
Molybdenum	1/2	3.2
Titanium	3/4	3.2
Zirconium	1/2	3.2
Copper	1	3.2

Next, some of the same electrodes were again placed in the same saturated solution of sodium chloride, which, by this time also contained the chlorides of most of the metals tested. The values are shown in Table III. No actuation of the warning device was obtained in these instances.

Table III

Metal	Distance, inches	Area, inches	Voltage
Stainless steel	Touch	3/4	3
Zinc	do	3/4	3
Iron	do	0 to 1	3
Aluminum	do	Point	3.2
Do	1/16	1/2	6
Platinum	Touch	1/4	3.2
Nickel	do	Edge	3.2
Do	.001	1	3.2
Molybdenum	.001	1/2	3.2
Titanium	.005	4	3.2
Zirconium	Touch	End	3.2
Do	1	1	6.5

A further test of some of the metals was made, the same as the other tests, except in a solution of gold chloride, with no actuation of the warning device in any of the following instances:

Table IV

Metal	Distance, inches	Area, square inches	Voltage
Platinum-----	.05-----	.15-----	3.2
Do-----	.1-----	.2-----	10
Nickel-----	.05-----	.2-----	3.2
Zirconium-----	Touch-----	.2-----	3.2
Do-----	.001-----	.2-----	10

If the circuit values are chosen so that low voltages (e.g., about 1 to 2½ volts) are applied across the responder or thermal switch, even when the responder or switch is exposed to conductive electrolyte, optimum results can be obtained.

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. An alarm circuit that will not be shorted out to give false warnings in the presence of moisture and of electrolytic solutions, including in combination: a source of electrical current; indicator means in series with said source responsive after a short time interval following application of energy thereto of a predetermined minimum power value for operation; actuator means normally having a high impedance state and operable to a low impedance state, in series with said source and said indicator means, and providing, in said high impedance state, sufficient impedance in said circuit to hold the current passing to said indicator means below said minimum value, and when in said low impedance state, causing operation of said indicator means, said actuator means also having exposed normally conductive connections, which, when exposed to an electrolytic solution, tend to provide a bypass around said actuator means; and means including said current, which would then tend to be bypassed through such an electrolytic solution, for passivating said connections in the event of such by-passing so that an impedance between said exposed connections through said solution reaches a value preventing bypassing of sufficient current to actuate said indicator means within a time interval shorter than that by which the indicator means can be actuated, said passivation on affecting normal, true-alarm operation.

2. An alarm circuit that will not be shorted out to give false warnings in the presence of moisture and of electrolytic solutions, including in combination: a source of electrical current; indicator means in series with said source having a delayed response to an application of a predetermined minimum value of power for operation; actuator means having a normally open switch in series with said source and said indicator means, and providing when said switch is open, sufficient impedance in said circuit to hold the current passing to said indicator means below said minimum value, and providing, when said switch is closed, nearly zero impedance, causing operation of said indicator means, said actuator means also having conductive connections on opposite sides of said switch means which, when exposed to an electrolytic solution, tend to provide a bypass short around said switch means; and means in said circuit for providing through such a solution a certain minimum current value and a certain maximum voltage drop across said connections and also providing voltage-current values at said actuator means, such that said current across said con-

nections quickly passivates them to provide an impedance between them such that the voltage thereacross is unable to break it down and does so before said indicator means can be operated initially by the voltage-current values applied there, so that thereafter such operation by said solutions is entirely prevented, without impairing normal true-alarm operation.

3. The alarm circuit of claim 2 having circuit ground-test means for purposely and at separate times grounding each side of said normally open switch, so that if the opposite side of said switch has been unintentionally grounded there will be a dead short contacting ground around said switch, and means for indicating the presence of said dead short.

4. The alarm circuit of claim 3 wherein said last-named means comprises an ammeter calibrated in terms of the length of circuit components for indicating approximately the location of the unintentional ground.

5. The alarm circuit of claim 2 having circuit integrity test means for sending therethrough, when used, a greatly increased voltage sufficient to pass through the impedance of said actuator means when said switch is open enough current to actuate said indicator means and thereby show that the circuit integrity is maintained.

6. A control circuit that will not be shorted out to give false warnings in the presence of moisture and of electrolytic solutions, including in combination: a source of electrical current; indicator means in series with said source having a delayed response to an application of a predetermined minimum value of power for operation; actuator means having a normally open switch in series with said source and said indicator means, and providing when said switch is open, sufficient impedance in said circuit to hold the current passing to said indicator means below said minimum value, and providing, when said switch is closed, nearly zero impedance, causing operation of said indicator means, said actuator means also having normally exposed conductive connections on opposite sides of said switch means which, when exposed to moisture or an electrolytic solution, tend to provide a bypass short around said switch means, the impedance of the circuit at a predetermined operating voltage thereof providing a certain minimum current value and a certain maximum voltage drop across said connections and also providing voltage-current values at said actuator means, such that said current across said connections quickly passivates them to provide an impedance between them such that the voltage thereacross is unable to break down and does so before said indicator means can be operated initially by the voltage-current values applied there, so that thereafter such operation by said solutions is entirely prevented, without impairing normal true-alarm operation.

7. A temperature-detection system comprising an electrically conductive tube containing non-electric means for releasing significant quantities of gas when heated to a predetermined temperature; an electrically conductive diaphragm; a housing divided by said diaphragm into two chambers, namely, a first chamber in communication with the interior of said tube and a second chamber isolated therefrom; an electrode in said second chamber against which said diaphragm is closed by movement of said diaphragm due to a predetermined increase in pressure in said first chamber; an above-ground electrical circuit connecting said electrode in series with said diaphragm and a source of electrical current, said circuit having a return line from said diaphragm to said source and signal means in series with said electrode and actuated upon contact of said electrode by said diaphragm, said circuit also having an electrical resistor in parallel with said electrode and diaphragm connected to said return line, the amount of current passing through said resistor normally being insufficient to actuate said signal means; and means for increasing the current flow through

said resistor to a level sufficient to actuate said signal means.

8. A temperature-detection system comprising an electrically conductive tube containing non-electric means for releasing significant quantities of gas when heated to a predetermined temperature; an electrically conductive diaphragm; a housing divided by said diaphragm into two chambers, namely, a first chamber in communication with the interior of said tube and a second chamber isolated therefrom; an electrode in said second chamber against which said diaphragm is closed by movement of said diaphragm due to a predetermined increase in pressure in said first chamber; an above-ground electrical circuit connecting said electrode in series with said diaphragm, and a source of electrical current, and having a first return line between said diaphragm and said source, said tube having a second return line to said source connected in parallel to said first return line, said circuit having signal means in series with said electrode and actuated upon contact of said electrode by said diaphragm, said circuit also having an electrical resistor in parallel with said electrode and diaphragm, the amount of current passing through said resistor normally being insufficient to actuate said signal means; first means for increasing the current flow through said resistor and said first return line to a level sufficient to actuate said signal means; and second means for increasing the current flow to a still higher level for passage through said resistor, said tube, and said second return line to a level sufficient to actuate said signal means.

9. An alarm circuit that will not be shorted out to give false warnings in the presence of moisture and of electrolytic solutions, including in combination: a source of electrical current; indicator means in series with said source responsive after a short time interval following

application of energy thereto of a predetermined minimum power value for operation; actuator means having normally open switch means in series with said source and said indicator means, and providing, when said switch means is open, sufficient impedance in said circuit to hold the current passing to said indicator means below said minimum value, and providing, when said switch means is closed, nearly zero impedance, causing operation of said indicator means, said actuator means also having exposed normally conductive connections on each side of said normally open switch means which, when exposed to an electrolytic solution, tend to provide a bypass around said switch means; and means including the current bypassed through such an electrolytic solution for passivating said connections so that an impedance between said exposed connection through said solution reaches a value preventing bypassing of sufficient current to actuate said indicator means within a time interval shorter than that by which the indicator means can be actuated, said passivation not affecting normal, true-alarm operation.

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,154,772

October 27, 1964

John E. Lindberg, Jr.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 53, for "on" read -- not --.

Signed and sealed this 1st day of June 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

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