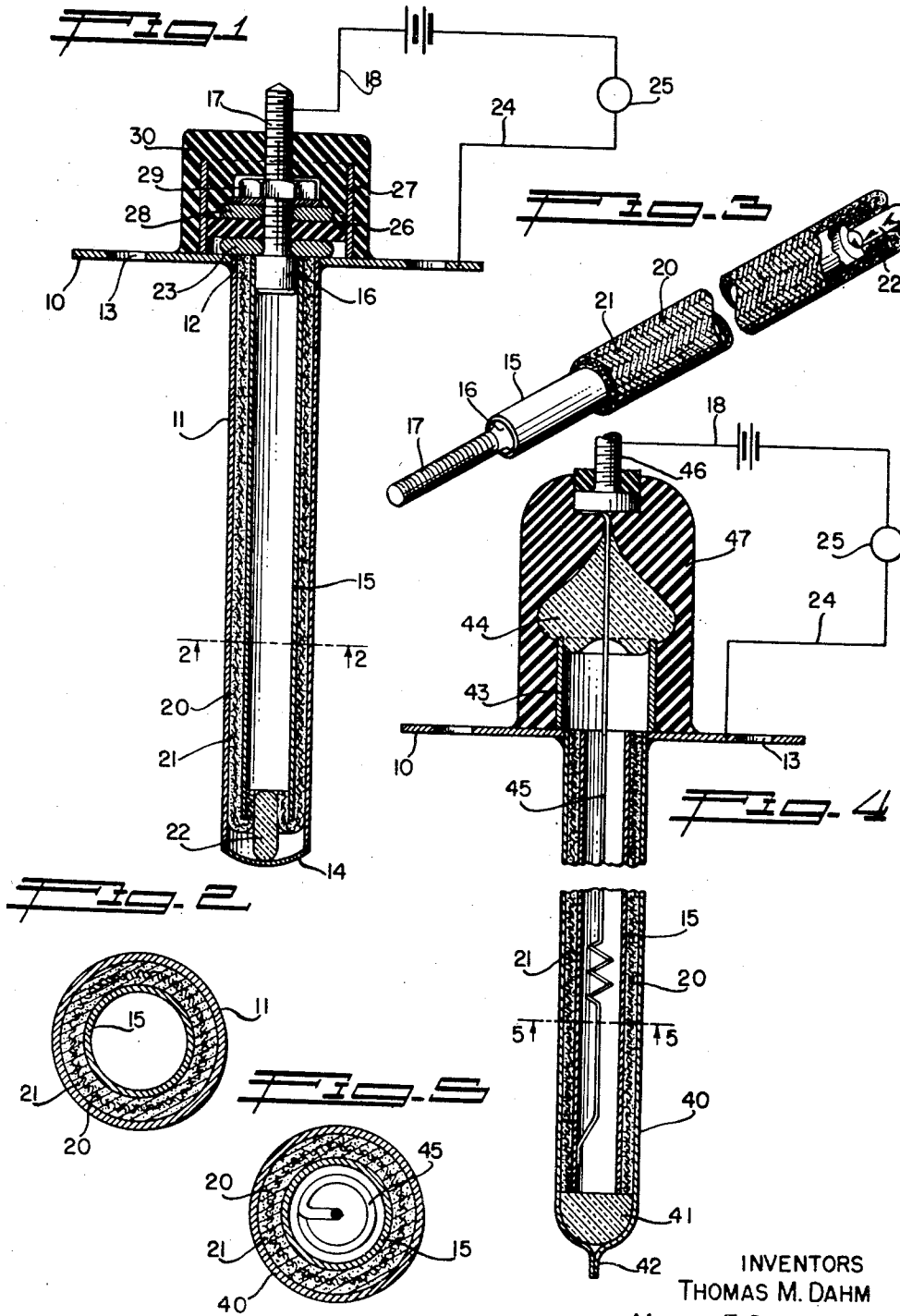


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ELECTRIC FIRE DETECTOR
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ELECTRIC FIRE DETECTOR

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1

This invention relates to temperature responsive devices and relates more particularly to devices of this character suitable for use as fire detectors and operable to control electrical circuits of fire warning and fire extinguishing systems.

Fire detectors have been suggested which embody a tube constituting one electrode of a circuit, a wire or conductor enclosed in the tube and forming the second electrode, the two tubes being spaced by a material which has a high electrical resistance at normal temperatures but which becomes conductive to complete a normally open circuit when the device is subjected to elevated temperatures. Such prior proposals have definite shortcomings which limit their successful practical applications. For example, means for sealing the outer tube are either absent or ineffective with the result that the material, usually a salt or salt mixture which becomes conductive at elevated temperatures, is adversely affected by atmospheric conditions, condensation of moisture, etc. rendering the device unreliable. Furthermore, the salt or material arranged between the electrodes of prior proposals either deteriorates with age and repeated use, or loses its sensitivity so that the temperature range in which the detector becomes operative is uncertain. These and other considerations tend to make the earlier detectors of this general class unreliable and therefore of little or no practical value.

It is a general object of this invention to provide an effective fire detector of the class above referred to that is positive and dependable in operation and that is substantially unaffected by aging at elevated temperatures or repeated usage. The device of this invention retains a given or selected range of temperature actuation following repeat operations and is unaffected by age, atmospheric conditions, etc. Accordingly, the device is adapted for installations where rekindling of a fire may occur and where the device is subject to non-critical temperature fluctuations, atmospheric variations, etc.

Another object of the invention is to provide a fire detector of the class mentioned that may be embodied in a relatively small, compact unit that is permanently hermetically sealed and suitable for spot installation, that is for installation in selected locations where fires are apt to occur or where special fire protection precautions are indicated.

Another object of the invention is to provide a fire detector of the character mentioned in which the inner electrode is in the form of a thin-walled metal tube which has a low heat ca-

2

capacity per unit area so as to rapidly rise in temperature upon receiving only a small amount of heat. This materially accelerates the action of the device. The salt which occupies the space between the two electrodes cannot melt through to close the electrical circuit until the surface temperature of the inner electrode has been raised to the melting point of the salt. Where the inner electrode is a solid rod or wire, as in prior devices, the action is slow because the electrode has a high heat capacity per unit area. In the present invention the outer electrode is a thin-walled tube to have a minimum temperature differential between its inner and outer surfaces when heated by a flame and to have a low heat capacity per unit area to transmit a maximum of heat to the salt. The thin-walled construction of the two electrodes increases the sensitivity of the detector to flame and elevated temperatures and is an important factor in increasing the rate of response of the device.

Another object of this invention is to provide a fire detector in which the salt is arranged or contained in a manner to materially increase the rate at which the heat reaches the inner electrode and therefore to increase the rate at which the salt will become electrically conductive to render the detector active. The salt is a poor thermal conductor and has considerable heat of fusion so that its presence between the electrodes reduces the rate at which the heat reaches the inner electrode. In the present invention, the salt is supported as thin layers on the multitudinous strands of a woven sleeve to normally constitute an effective dielectric between the two electrodes and yet be in a state or condition to offer a minimum of resistance to the transmission of heat between the outer and inner tubular electrodes.

Other objects and features of the invention will become apparent from the following detailed description of typical preferred forms throughout which description reference is had to the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of a detector of the present invention;

Figure 2 is an enlarged transverse sectional view taken as indicated by line 2-2 on Figure 1;

Figure 3 is a perspective view of the inner electrode assembly removed from the outer electrode;

Figure 4 is a longitudinal sectional view of another form of detector of the invention; and

Figure 5 is an enlarged transverse sectional view taken as indicated by line 5-5 on Figure 4.

The unit illustrated in Figures 1, 2 and 3, includes a mounting flange or plate 10 and an outer

tube 11 secured thereto. The plate 10 may be of any required or selected shape and construction. In the drawings, the plate 10 is a simple flat member provided with a central opening 12 and marginal openings 13, the latter being adapted to receive attaching screws or the like to facilitate the mounting of the detector. The tube 11 is an elongate part secured to the flange or plate 10 to project therefrom. The inner end of the tube 11 is engaged in the opening 12 and is fixed to the plate 10 by welding or by a solder having a high melting point. The outer end of the tube 11 is closed and sealed by a cap 14 welded, brazed, or soldered in place. The tube 11 constitutes one of the electrodes and is, therefore, formed of metal. We have found it desirable to construct both the tube 11 and the flange 10 of stainless steel. In accordance with the invention, the tube 11 has a thin wall, say below .007" thick. For example, the tube 11 may be formed of stainless steel tubing having a wall thickness of .005".

The inner electrode of the detector is in the form of a metal tube 15 arranged in the outer electrode 11 in coaxial relation thereto. The tube or electrode 15 extends from the plane of the flange 10 to adjacent the cap 14 and has a diameter smaller than the inside diameter of the outer tube 11, leaving an annular space between the two concentric electrodes. It is a feature of the invention that the tubular inner electrode 15 has a small wall thickness. The wall thickness of the tube 15 is preferably less than .007" and in practice may be .005". The head 16 of a terminal stud 17 is secured in the inner end of the tube 15 by silver solder, or the like. The stud 17 is employed as a post or terminal for one side or lead 18 of an electrical fire warning or fire extinguishing circuit and assists in securing the tube sealing means to be subsequently described.

The annular space between the above described tubular electrodes 11 and 15 contains a tubular sleeve 20 of glass threads or other dielectric or insulating fibrous material. This sleeve 20 serves as a carrier for the salt or salt mixture 21 indicated by the dots in the drawings. The impregnated sleeve rather closely fits around the inner electrode 15 and rather closely engages in the outer electrode 11. The outer end portion of the sleeve 20 is turned or wrapped around into the outer end of the inner electrode 15, and a plug 22 of glass or ceramic material is entered in the turned back part of the woven sleeve to retain it in position. The plug 22 is in turn engaged against the cap 14. While we have found this manner of securing the sleeve 20 to the inner electrode to be effective, it is to be understood that other appropriate means may be used for this purpose. The other end of the sleeve 20 occurs at or adjacent the corresponding ends of the two electrodes and a washer 23 is arranged on the stud to engage the end of the sleeve. The washer 23 may be metal having a covering of vitreous enamel or other dielectric material or may be aluminum with a heavy anodic coating. In any case the washer 23 must not electrically connect the electrode tubes 11 and 15.

The above mentioned salt or salt mixture 21 is impregnated in the woven screen 20 to form a spacer of high electrical resistance between the two electrodes 11 and 15, but upon approaching the fusion temperature the electrical resistance of the salt rapidly lessens and the salt then provides a path for the electricity to complete the circuit between the conductor 18 and the inner electrode 15 on the one hand and the outer elec-

trode 11 and a conductor 24 on the other hand. A fire warning device 25, a fire extinguishing device, or the like, is connected in the lead 24 to be energized when this occurs. The salt 21 is deposited on the surfaces of the sleeve 20 in relatively thin layers to absorb a minimum amount of heat and therefore increase the rate at which heat is conducted to the inner electrode 15.

Furthermore, the thin layers or coatings of the salt reduce the thermal insulating effect of the salt to a minimum. It will be observed that the sleeve 20 of glass fibers or the like, in addition to forming a carrier for the thin layers of salt constitutes a dependable mechanical insulator for preventing metallic short circuiting of the electrodes 11 and 15, even at a time when the salt 21 is fused. Such a short circuiting might persist after cooling and solidification of the salt.

The particular salt or salt mixture employed depends to a large degree upon the intended temperature at which the detector is to operate. For installations such as the engine nacelles of aircraft, where it is desired to have the fire detector operate at a temperature of between 425° F. and 430° F., we prefer to employ a salt mixture of 50% sodium nitrate and 50% sodium nitrite, all percentages referred to herein being mole percentages. We have found this to be superior to a sodium nitrate and potassium nitrate eutectic which melts sharply at approximately 424° F. The sodium nitrate and potassium nitrate mixture has a considerably reduced operating temperature after repeated operation, probably due to the fact that the system becomes a complex mixture of NaNO_3 , KNO_3 , NaNO_2 , and KNO_2 . In order to eliminate this, the system NaNO_3 , NaNO_2 is chosen wherein only salts of a single alkali metal are used and the chance of decomposition of the NO_3 to NO_2 is greatly decreased due to the equilibrium effect. Even though some decomposition of the nitrate ion to the nitrite ion does occur, the salt system remains binary. The conductivity point or that point at which the initial melting of the salt mixture occurs remains unchanged due to the presence of the eutectic. The preferred mixture melts at 428° F. although there may be slight variations in the melting point after repeated operations. Various lead and silver halides may be used but due to electrolysis effects they form products which render them unsuited where metallic containers or electrodes are employed. On the other hand, alkali metal and alkaline earth metal ions are not readily plated out from their salts and do not corrode the stainless steel electrodes 11 and 15. Accordingly alkali metal and alkaline earth metal salts are preferred.

It is contemplated that the mechanical features of the detectors may be made standard and that the salts may be varied or changed to alter the operative temperatures of the units for given installations. For example, where the operative temperature is to be 600° F. the sleeve 20 may be provided with a deposit or covering of 20% potassium nitrate and 80% potassium nitrite and when the operative temperature is to be 480° F. 100% lithium nitrate may be used. Again, where the operative temperature is to be 525° F. 100% sodium nitrate may be provided on the sleeve and where the device is to operate at a lower temperature of about 350° F. 62% thallium nitrate and 28% potassium nitrate may be used.

The electrode assembly is hermetically sealed to assure consistent and reliable operation of the

detector. The sealing means includes a synthetic rubber washer 26 engaged against the top of the washer 23. A tubular metal cage 27 is brazed or otherwise fixed to the flange 10 and the washer 26 is pressed into the cage to bear against the washer 23. An outer washer 28 of metal or the like is arranged on the outer side of the synthetic washer 26 and a nut 29 is threaded on the stud 17 to squeeze or force the washer 26 into tight effective sealing engagement with the stud, the washer 23 and the cage 27. A cap 30 of synthetic rubber is vulcanized on the cage 27, stud 17 and washer assembly to provide the hermetic seal.

In assembling the device the impregnated woven sleeve 20 is slipped over the inner electrode 15 and is then inserted in the outer electrode 11. It is preferred to heat the parts to the melting point of the salt before performing these operations to provide lubrication and to protect the sleeve 20 against injury. The assembly is then dried thoroughly until it operates at between 410° F. and 420° F. whereupon the above described washer arrangement is assembled to prevent subsequent moisture absorption by the salt. The final step in the assembly is the vulcanizing on of the cap 30 to provide the hermetic seal.

Figures 3 and 5 of the drawings illustrate a detector of the invention which is sealed by a glass closure and a synthetic rubber cap. In this construction the flange 10, inner electrode 15, sleeve 20 and electrical circuit may be the same as described above and corresponding reference numerals are applied to these parts. The outer electrode 40 is substantially the same as in the previously described form of the invention, however the outer end of the electrode is formed over a glass block 41 and its end is closed by welding at 42. A tubular cage or shell 43 is secured to the flange 10 in coaxial relation to the electrodes and is closed by a body or closure 44 of glass applied to the end of the shell while in a molten state. A wire 45 is embedded or cast in the glass closure and extends into the inner electrode 15. The outer end of the wire 45 is brazed or soldered to the interior of the electrode 15 and the opposite end of the wire is secured conductively to a threaded terminal stud 46. It is preferred to allow coiled slack in the wire 45 to facilitate the attachment of the wire to the electrode 15, either subsequent to or prior to formation of closure 44 and prior to arranging the block 41 in place. Following the assembling, drying and initial glass sealing of the unit, a cap 47 of synthetic rubber or the like, is vulcanized on the shell 43 and glass closure 44 to constitute the final hermetic seal.

It is believed that the operation of the detectors will be readily understood from the foregoing detailed description. Referring now to the embodiment of the invention illustrated in Figures 1 to 3, the flange 10 may be employed as a means for mounting the detector in the selected position. The detector, being small and compact, may be readily mounted at or adjacent the point where fire is likely to occur or where fire protection is important. Under normal conditions, that is when the temperature is well below the fusion point of the salt 21, the electrical circuit of the fire warning or fire extinguishing device 25 remains open owing to the fact that the salt 21 constitutes an insulator or body of high electrical resistance between the two electrodes 11 and 15. However, when the temperature of the electrodes

approaches the melting point of the salt, for example when the fire detector is subjected to a flame, the thin deposit of salt on the sleeve 20 rapidly reaches a temperature where it constitutes a good electrical conductor between the two electrodes. The electrical conductivity of the salt rather rapidly increases before and after the melting point is attained. As described above, the thin-walled construction of the tubes 11 and 15, and the impregnation of the fiber glass sleeve 20, contribute materially to the rapid action of the detector when subjected to the elevated temperature. When the circuit is completed through the salt, the device 25 is operated. Subsequently, when the fire detector has cooled, the salt 21 returns to its solid condition and again forms a body or sheath of high electrical resistance between the electrodes 11 and 15. The detector is capable of numerous repeat operations; for example it will again close the electrical circuit to the device 25 in the event the original fire rekindles or a second fire subsequently develops.

Having described only typical forms of the invention we do not wish to be limited to the specific details herein set forth, but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

We claim:

1. A device of the class described comprising a tubular outer electrode, a tubular thin-walled inner electrode of low heat capacity per unit area enclosed by and spaced from the inner wall of the outer electrode, a fusible salt composition in the space between the inner electrode and said inner wall that is non-conductive when cold and that becomes conductive when it approaches the fusion temperature, and means hermetically sealing the ends of the outer electrode.

2. A device of the class described comprising a tubular outer electrode, a tubular inner electrode enclosed by and spaced from the inner wall of the outer electrode, a fusible salt composition in the space between the inner electrode and said inner wall that is non-conductive at normal temperatures and that becomes conductive when its temperature approaches the fusion temperature, means closing one end of the outer electrode, a terminal on the inner electrode extending beyond the other end of the outer electrode, and a hermetic seal for said other end of the outer electrode.

3. A flame and temperature sensitive device comprising a tubular outer electrode, a tubular inner electrode within the outer electrode, there being an annular space between the inner electrode and the internal wall of the outer electrode, a tubular woven sleeve of non-conductive material occupying said annular space and surrounding the inner electrode, and a salt impregnated in said woven sleeve that remains non-conductive until its temperature approaches the fusion temperature whereupon it becomes conductive to provide an electrical path between said electrodes.

4. A flame and temperature sensitive device comprising a thin walled tubular outer electrode, a thin walled tubular inner electrode within the outer electrode, there being an annular space between the inner electrode and the internal wall of the outer electrode, a tubular woven sleeve of non-conductive material arranged in said annular space to surround the inner electrode, and a salt impregnated in said woven sleeve that remains non-conductive until its temperature approaches the temperature of fusion whereupon it

becomes conductive to provide an electrical path between said electrodes.

5. A flame and temperature sensitive device comprising a tubular outer electrode, a tubular inner electrode within the outer electrode, there being an annular space between the inner electrode and the internal wall of the outer electrode, a tubular woven sleeve of non-conductive material arranged in said annular space to surround the inner electrode, means for closing and sealing one end of the outer electrode, a terminal stud on the inner electrode extending beyond the other end of the outer electrode, an hermetic seal means closing said other end of the outer electrode and sealing around said stud, and a salt impregnated in said woven sleeve that is non-conductive when cold and that is conductive to provide an electrical path between said electrodes when its temperature approaches the temperature of fusion.

6. A device of the character described comprising a closed hollow outer electrode, a thin walled tubular inner electrode within the outer electrode, the inner electrode being spaced from the inner wall of the outer electrode to leave an annular space, a porous tubular woven sleeve of non-conductive material arranged in said space to surround the inner electrode, and fusible salt diffused through the pores of said sleeve, said salt being non-conductive until it approaches the temperature of fusion whereupon it becomes conductive to form an electrical path between said electrodes.

7. A device of the character described comprising a closed hollow outer electrode, a thin walled tubular inner electrode within the outer electrode, the inner electrode being spaced from the inner wall of the outer electrode to leave an annular space, a porous tubular woven sleeve of non-conductive material in said space, and a mixture of sodium nitrate and sodium nitrite diffused through the pores of said sleeve, said mixture being non-conductive until it approaches the temperature of fusion whereupon it becomes conductive to form an electrical path between said electrodes.

8. In a device of the class described, the combination of two tubular electrodes in spaced substantially concentric relation, a sleeve of woven glass fibers arranged in the space between the electrodes, and a salt composition impregnated in said sleeve, said salt composition being non-conductive until it approaches the temperature of fusion whereupon it becomes conductive to provide an electrical path between said electrodes.

9. In a device of the class described, an outer tubular electrode, an inner electrode within the outer electrode and spaced from the wall thereof to leave an annular space, a porous sleeve of woven glass fibers in said space, and a mixture of sodium nitrate and sodium nitrite diffused through the pores of said sleeve, said mixture being non-conductive when cold and being conductive when it approaches the fusion temperature.

10. A device of the character described comprising a tubular outer electrode having an end wall closing one of its ends, a tubular inner electrode within the outer electrode and spaced from the wall thereof to leave an annular space, a woven sleeve of dielectric material in said space, a salt composition impregnated in said sleeve and non-conductive when cold but conductive to provide an electrical path between the electrodes when it approaches the fusion temperature, a

terminal engaged in the inner electrode and extending beyond the other end of the outer electrode, a washer assembly on the terminal for sealing said other end to the outer electrode, and a nut threaded on the terminal to actuate said assembly.

11. A device of the character described comprising a tubular outer electrode having an end wall closing one of its ends, a tubular inner electrode within the outer electrode and spaced from the wall thereof to leave an annular space, a woven sleeve of dielectric material in said space, a salt composition impregnated in said sleeve that is non-conductive when cold but conductive to provide an electrical path between the electrodes when it approaches the fusion temperature, a terminal secured to the inner electrode and extending beyond the other end of the outer electrode, a washer assembly on the terminal for sealing said other end of the outer electrode, and a sealing cap vulcanized on the terminal and said assembly.

12. A device of the character described comprising a tubular outer electrode having an end wall closing one of its ends, a tubular inner electrode within the outer electrode and spaced from the wall thereof to leave an annular space, a woven sleeve of dielectric material in said space, an end portion of the sleeve being wrapped about an end of the inner electrode and engaged in the interior thereof, a plug engaged in said portion of the sleeve to secure the sleeve to the inner electrode and engaging said end wall of the outer electrode, a salt composition impregnated in said sleeve that is non-conductive when cold but conductive to provide an electrical path between the electrodes when it approaches the fusion temperature, a terminal secured to the inner electrode and extending from the other end of the outer electrode, a washer assembly on the terminal for sealing said other end of the outer electrode, and a nut threaded on the terminal to actuate said assembly.

13. A device of the class described including a tubular outer electrode, means closing one end of the outer electrode, a tubular inner electrode spaced from the wall of the outer electrode to leave an annular space, a porous woven sleeve of dielectric material in said space, a salt composition diffused through the pores of the sleeve that is non-conductive until it approaches the fusion temperature whereupon it becomes conductive to form an electrical path between the electrodes, a glass closure sealing the other end of the outer electrode, and a wire embedded in and extending through the glass closure and connected with the inner electrode.

14. In a device of the class described, a tubular outer electrode, a thin walled tubular inner electrode within and spaced from the wall of the outer electrode to leave an annular space, a porous sleeve of woven glass fibers in said space, and a mixture of approximately 50% sodium nitrate and approximately 50% sodium nitrite diffused through the pores of said sleeve.

15. A device of the character described comprising a closed hollow outer electrode, a thin walled tubular inner electrode within the outer electrode, the inner electrode being spaced from the inner wall of the outer electrode to leave an annular space, a relatively thin tubular woven sleeve of non-conductive material in said space, and a thin layer of salt on said sleeve that is non-conductive until the temperature of fusion of

the salt is approached whereupon it becomes conductive to provide an electrical path between the electrodes.

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