United States Patent [19]

Scarelli

[11] **3,774,184**

[45] **Nov. 20, 1973**

[54] **HEAT RESPONSIVE CABLE ASSEMBLY**

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[52] **U.S. Cl.** ..... **340/227 C,** 338/26

[51] **Int. Cl.** **G08b 17/00**

[58] **Field of Search** ..... 340/227 C, 227.1, 340/227, 228; 338/26

[56] **References Cited**

UNITED STATES PATENTS

2,992,310	7/1961	Babany	340/227 C
2,185,944	1/1940	Holmes	340/227 C
3,842,648	7/1958	Reynolds	340/227 C
3,257,530	6/1966	Davies	340/227 C
2,948,789	8/1960	Caldwell	340/227 C
2,518,789	8/1950	Jackson	340/227 C

Primary Examiner—John W. Caldwell
Assistant Examiner—Scott F. Partridge
Attorney—Harvey B. Jacobson

[57] **ABSTRACT**

A heat responsive cable assembly for use with a fire alarm system, or the like, said assembly comprising a pair of helically twisted conductors of substantially the same thermal expansion rates, the wires being plastically deformed during twisting, with a medium of heat sensitive insulation therebetween which is removed in response to predetermined high temperature conditions to permit contact between the conductors due to random thermal expansions and changes in helix angles of adjacent sections of the conductors.

5 Claims, 8 Drawing Figures

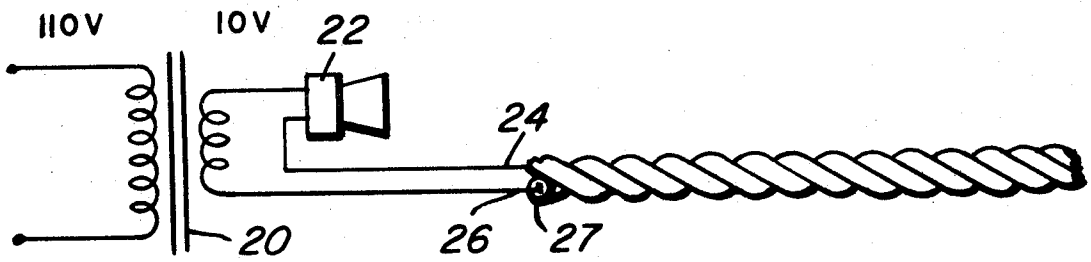


Fig. 1

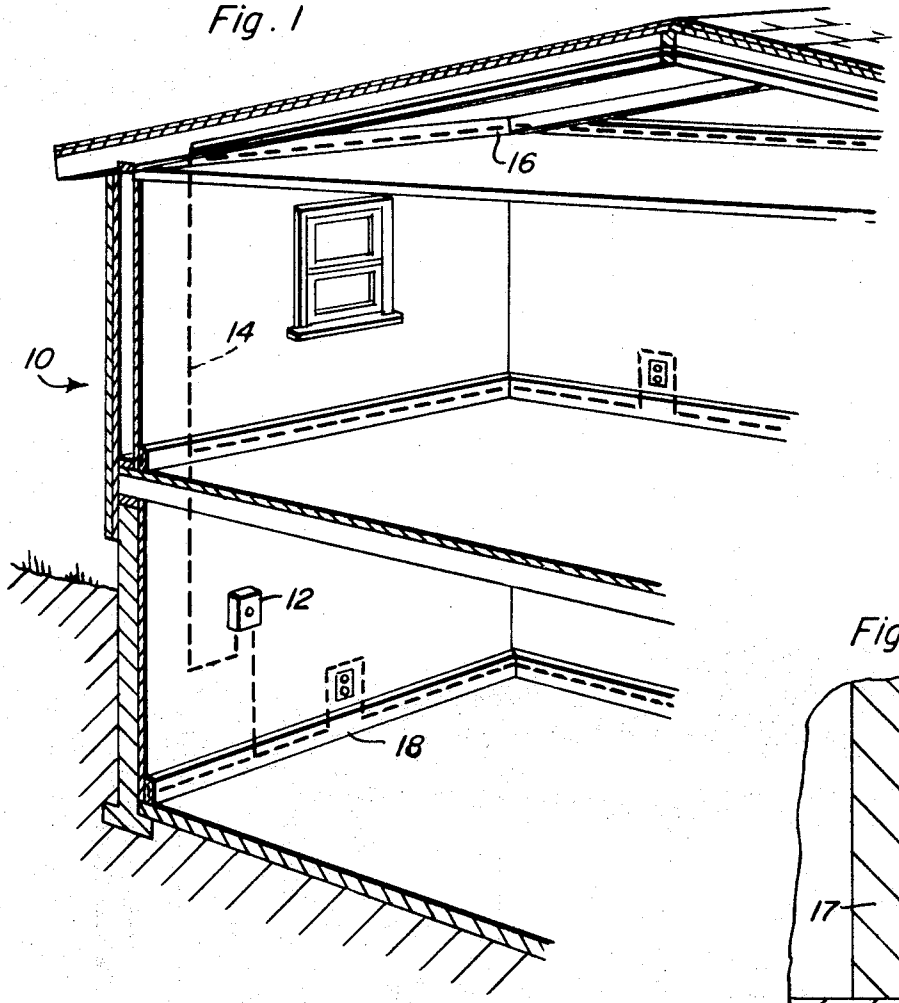


Fig. 2

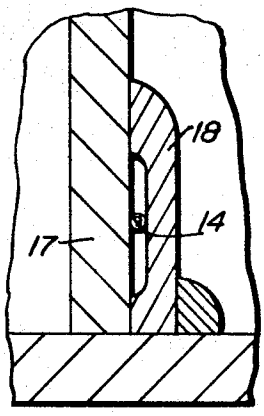


Fig. 3

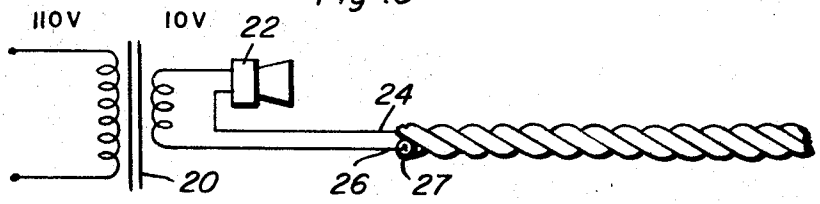


Fig. 4

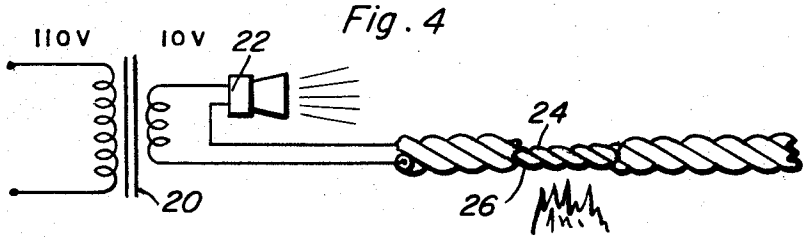


Fig. 5

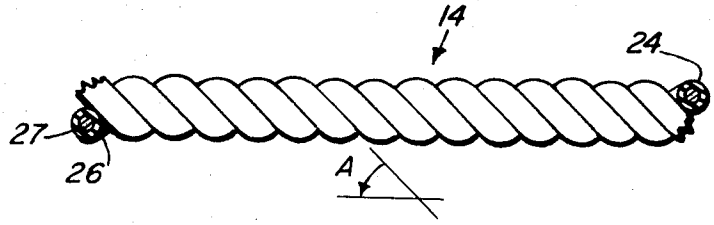


Fig. 6

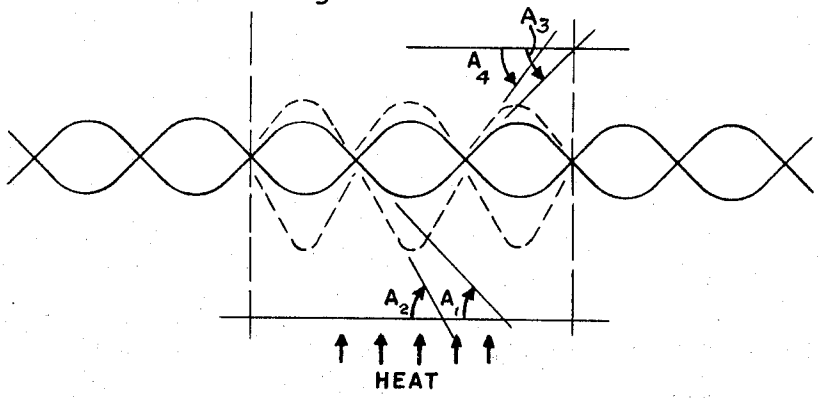


Fig. 7

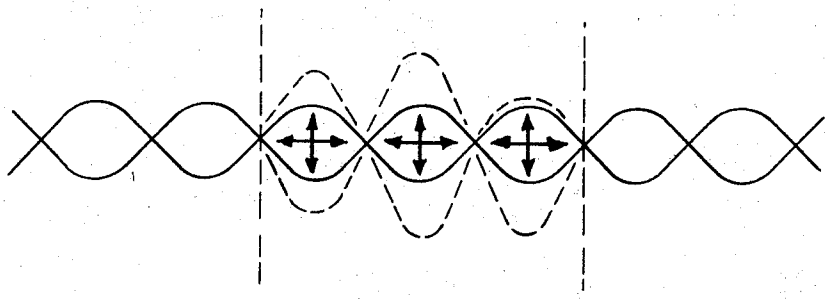
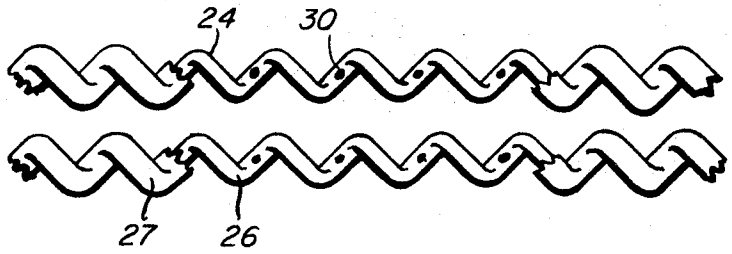


Fig. 8



HEAT RESPONSIVE CABLE ASSEMBLY

The present invention is generally related to fire alarm systems and, more particularly, to an improved heat responsive cable for detecting predetermined high temperature conditions activating an alarm, or similar device.

In the past, a large number of fire detecting devices and alarm systems have been proposed. The use of intertwined conductors to complete an electrical circuit in response to a high temperature condition was disclosed by the Holmes U.S. Pat. No. 2,185,944. The Holmes structure was limited to at least one of the conductors being of spring quality, such that it was biased toward the other conductor upon burning away of the intermediate insulation. This type of construction was costly to manufacture and install, it being necessary to encase the entire length of conductors with a relatively heavy shielding to prevent untwisting.

The U.S. Pat. to Jackson, No. 2,518,789, discloses a heat responsive cable assembly having a standard conductor with a fusible conductive material between the strands which flows to assure proper electrical contact with the adjacent conductor when exposed to a predetermined high temperature condition. While the Jackson construction does not require the use of a spring-type conductor or expensive outer shielding, the stranded conductor with fusible material is also expensive to manufacture even on a mass production bases.

More recently, fire detecting cable assemblies have been developed which utilize hydrates to complete a circuit between a pair of intertwined conductors. Such a construction is disclosed by the Caldwell, U.S. Pat., No. 2,948,789, and incorporates a hydrate of alum in the insulating fabric surrounding the conductors, such that water of crystallization is released upon reaching a predetermined high temperature. While the Caldwell construction does not require the use of spring wires, such as the Holmes structure, or a stranded conductor, such as that disclosed by Jackson, it is costly to produce the hydrate saturated fabric covering surrounding each conductor to assure sufficient water of crystallization to complete the circuit when exposed to a predetermined high temperature condition. Furthermore, deterioration over a period of years may render the Caldwell device inoperative.

It is desirable, therefore, to provide an inexpensive heat responsive cable assembly which is compact, reliable and easy to install in buildings, and the like, to detect a fire or other high temperature conditions.

It is an object of the present invention to provide a novel heat responsive cable assembly which is comprised of a pair of solid conductors which are helically entwined about each other in a predetermined dimensional relationship which assures contact between the conductors due to random thermal expansion and the change in helix angle between adjacent lays of the conductors when exposed to predetermined high temperature conditions.

Another object of the present invention is to provide a versatile heat responsive cable assembly comprised of a pair of twisted solid conductors of approximately 18–50 AWG and of substantially the same thermal expansion rates separated by a medium of heat sensitive insulation of approximately 0.003 inch or less thickness, whereby the adjacent conductors engage each other upon exposure to a predetermined high temperature condition.

It is a further object of the present invention to provide a unique heat responsive cable assembly comprising intertwined conductors with a medium of insulation therebetween, the assembly being extremely compact, permitting installation in small spaces, and the insulation having non-flame conveying characteristics even when exposed to fire or similar high temperature conditions normally presenting a fire hazard, thereby eliminating the possibility of spreading a fire from one area to another by way of the heat responsive cable assembly itself.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a partial perspective view of a typical house structure with the heat responsive cable assembly of the present invention installed therein.

FIG. 2 is a sectional view of the cable assembly of the present invention positioned within a groove of a piece of molding associated with the house structure.

FIG. 3 is a simplified diagram of a typical alarm system utilizing the cable assembly of the present invention.

FIG. 4 is a simplified diagram of the alarm system and associated cable assembly exposed to a predetermined high temperature condition.

FIG. 5 is an enlarged elevational view of a length of heat responsive cable assembly of the present invention.

FIG. 6 is a graphical representation of the change in helix angle of the twisted conductors.

FIG. 7 is a graphical representation of the random thermal expansion which occurs at different locations along a length of the cable assembly when exposed to a hazardous fire condition.

FIG. 8 is an elevational view of a typical length of disassembled cable after exposure to a high temperature condition.

Referring now, more particularly, to FIGS. 1 and 2, a typical application of the heat responsive cable assembly of the present invention is illustrated as being installed in a house structure generally indicated by the numeral **10**. A central control box and alarm **12** is installed at a convenient location and connected to a source of voltage, not illustrated. The lengths of the cable assembly of the present invention are illustrated in phantom and are indicated by the numeral **14**. Each length of cable is installed within the housing structure to detect high temperature conditions at locations most commonly experiencing such temperatures due to typical fire hazards. The compact construction of the cable assembly permits easy installation throughout the building structure. Preferably, the cable is located above and parallel to all electrical outlets and structures, and any cooking, lighting, or heating systems within the building. In addition, it has been found desirable to install a length of the cable assembly at the base of the roof structure inbetween wall openings, as indicated at **16**, where natural air currents may possibly ignite combustible gases. The cable may also be installed along the base of each wall **17** within the confines of a

longitudinal groove normally provided in baseboards, such as that indicated at **18.**

Referring now, more particularly, to FIGS. **3** and **4,** the operation of the cable assembly of the present invention may be more fully understood. Preferably, the cable is connected to a voltage source, such as 110 VAC as illustrated in the drawings, by way of a transformer **20,** to apply 10 volts to the cable conductors. In a typical dwelling installation, the existing doorbell circuit transformer may be utilized, or, if desired, a separate transformer may be provided. Of course, the cable assembly may be designed to operate on higher or lower voltages, as required. The system is provided with an alarm, such as the horn indicated at **22** connected in series with the transformer secondary and the heat responsive cable assembly. The cable assembly is comprised of a pair of helically twisted conductors **24** and **26** which are separated by a medium of polyurethane insulation **27,** or similar heat sensitive dielectric material. Under normal temperature conditions, the conductors remain dielectrically insulated from each other to assure that the alarm circuit remains deenergized. It will be appreciated that the remote ends of each length of cable are cut and positioned apart from each other to assure that the conductor ends do not make contact under normal temperature conditions. If desired, several lengths of cable may be connected in parallel with a circuit-testing switch at the end of each length to selectively close the circuit for alarm testing purposes.

When a section of the cable assembly is exposed to a predetermined high temperature condition, the dielectric insulation separating the conductors is burnt, softened, or volatilized to expose adjacent sections of each conductor which contact each other, thereby energizing the alarm system. Preferably, the dielectric insulation is such that it burns or gases away under the high temperature conditions without leaving significant residue or contamination on the conductors, thereby assuring proper contact and alarm energization. In the tests performed, it was found that polyurethane insulations provided the best results. Of course, other plastics and insulating materials may be utilized if they do not leave a residue on the conductors which would prevent energization of the alarm system.

FIG. **4** illustrates a typical situation where a flame or similar high temperature condition causes removal of the insulation separating the conductors along a relatively short length of the cable. It will be appreciated that since the alarm system depends upon the completion of a circuit, there are no operational or maintenance costs until the cable assembly is actuated by fire or a high temperature condition. In addition, the damaged length of cable may be easily replaced without wasting the undamaged sections.

Referring to FIGS. **5—8,** the detailed structure of the cable assembly of the present invention may be more fully appreciated. It has been found that by providing the proper insulation thickness, conductor separation, helix angle, and rate of thermal expansion, contact between the helically wound conductors is assured under high temperature conditions. Each conductor is of relatively soft, deformable material, such as copper or aluminum, and is solid in cross section. The conductors are helically twisted about each other such that the helical axes are in substantial alignment. Thus, a helix angle A is provided dependent upon the number of twists per unit axial length of the conductors. Preferably, the co-efficient of expansion which is relatively high to provide the required random deformation which aids in achieving contact between adjacent sections of conductor under high temperature conditions.

When a section of the heat responsive cable assembly of the present invention is exposed to a predetermined high temperature condition, the expansion of each conductor within the heated section causes distortion which may be defined as a change in helix angle, illustrated in FIG. **6.** Assuming that there is a helix angle A_1 under normal temperature conditions and that heat is applied from below the cable assembly, such as is normally the situation brought about by a flame or the convaction of hot gases prior to combustion, the lower halves of each helix will undergo a significant change in helix angle, represented by A_2. This change in helix angle is effective to change the position of one conductor relative to the other to effect contact therebetween for the completion of the alarm circuit. It will also be appreciated that within each short section of cable exposed to a temperature increase, the portions of a single helix will experience a slightly different temperature and, thus, expand accordingly. For example, the upper section of the conductors illustrated in FIG. **6** would experience less temperature increase than the corresponding opposite bottom sections, thereby providing two additional helix angles A_3 and A_4 which increase the probability of contact between adjacent sections of the exposed conductors. It should also be noted that the temperatures will vary somewhat from one twist of conductor to the other to provide a random type deformation of the twisted conductors which is also effective to produce contact points, as indicated at **30** in FIG. **8,** for completion of the alarm circuit. This random deformation may occur in all directions, as illustrated in FIG. **7.** Thus, it will be appreciated that each substantially short section of cable which is exposed to a temperature increase will assume several helix angles and will experience random deformation, both of which are effective to cause contact between the conductors.

In order to assure that contact occurs between the conductors, it is essential that the separation and normal helix angle be maintained within predetermined limits. It has been found that proper contact is assured when utilizing conductors of 18 to 50 AWG with an insulation thickness and conductor separation not exceeding 0.003 inch and preferably with 12 or more twists per axial foot of conductor. While the exact mathematical relationships between these parameters has not been correlated, it is clear from the test data that a reliable heat responsive cable assembly may be provided when remaining within certain parameter limitations. A partial list of this test data is as follows:

Conductors No.	AWG	Insulation Type	Inch	Twists/ foot	Propane Torch Application Bell rang
					constantly
2	26	poly-ure-thane	.0015	48	after 1 second
				36	after 1 second
				12	after 1 second
				4	after 1 second
2	22	poly-ure-thane	.0015	36	after 5 seconds
				12	after 5 seconds
				4	after 5 seconds
1	22	poly-ure-thane	.0015		

1	22	none	12	after 3 seconds

From the above data, it is conclusive that when utilizing 22 AWG copper conductors of solid cross-section with the indicated insulation coverings of polyurethane not exceeding 0.003 inch between the conductors and with at least 4 helical twists per foot, adequate contact was made between the conductors exposed to a predetermined temperature condition representative of a fire or similar hazard. Most often these contact areas were visible at spaced points along the helical lengths of conductor when disassembled, as illustrated in FIG. 8. While an increase in the number of helical twists per length of cable did not necessarily produce a faster response or better contact, it is apparent from a mathematical standpoint that the probability of contact increases with the number of twists per foot since the length of exposed conductors and possible contact points per length of cable are increased as well as the number of random expansions along the heated section. Of course, it should be noted that different types of insulations may be utilized if they do not leave a significant residue which may possibly hamper contact between the conductors. Several tests were performed with polyvinylchloride and polyolefin insulation materials. However, the polyvinylchloride left a significant residue and the polyolefin conveyed a flame to an undesirable extent.

From the foregoing description, it will be appreciated that the heat responsive cable assembly of the present invention may be made from standard copper conductors with plastic dielectric insulation coatings. Since contact is assured by the random distortion and helix angle changes, it is not necessary to utilize expensive spring-type conductors, hydrates, or stranded conductors as required by the structures disclosed by Holmes, Caldwell, and Jackson patents discussed above. The cable assembly of the present invention may be produced at a fraction of the cost of such conventional construction and its installation is relatively inexpensive due to the compactness and flexibility of each length of cable. Furthermore, the cable does not require electrical energy until a high temperature condition is sensed. Also, damaged sections of cable may be easily replaced between adjacent undamaged sections. It will be appreciated that the cable assembly may be

utilized with alarm systems other than illustrated in FIGS. 3 and 4, such changes being deemed to fall within the scope of the present invention.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed as new is as follows:

1. In combination with a fire alarm system having a voltage source, a heat responsive cable assembly comprising a single pair only of solid electrical conductors of relatively soft, deformable material helically twisted about each other, said conductors being connected to said fire alarm system voltage source, and a medium of heat sensitive electrical insulation normally between said conductors, said heat sensitive insulation being removed from between said conductors in response to a predetermined high temperature condition to expose said conductors for engagement with each other, said conductors normally being spaced from each other by a distance of approximately 0.003 inch and being helically twisted at least 35 turns per foot of axial length, said conductors having relatively high rates of thermal expansion such that they are significantly expanded when exposed to said predetermined high temperature condition to provide different helix angles between adjacent sections of said conductors and effect contact therebetween, both of said conductors having substantially the same rate of thermal expansion and said insulation gasing off at said predetermined high temperature condition to provide clean contact areas on each conductor.

2. The structure set forth in claim **1**, wherein said conductors are each between 20 to 50 AWG.

3. The assembly set forth in claim **1**, wherein said insulation is polyurethane.

4. The structure set forth in claim **1** wherein said voltage source is less than 25 volts.

5. The structure set forth in claim **4** wherein said voltage source is approximately 10 volts alternating current.

* * * * *