May 10, 1960 R. H. POSTAL 2,936,434

FIRE DETECTOR CABLE

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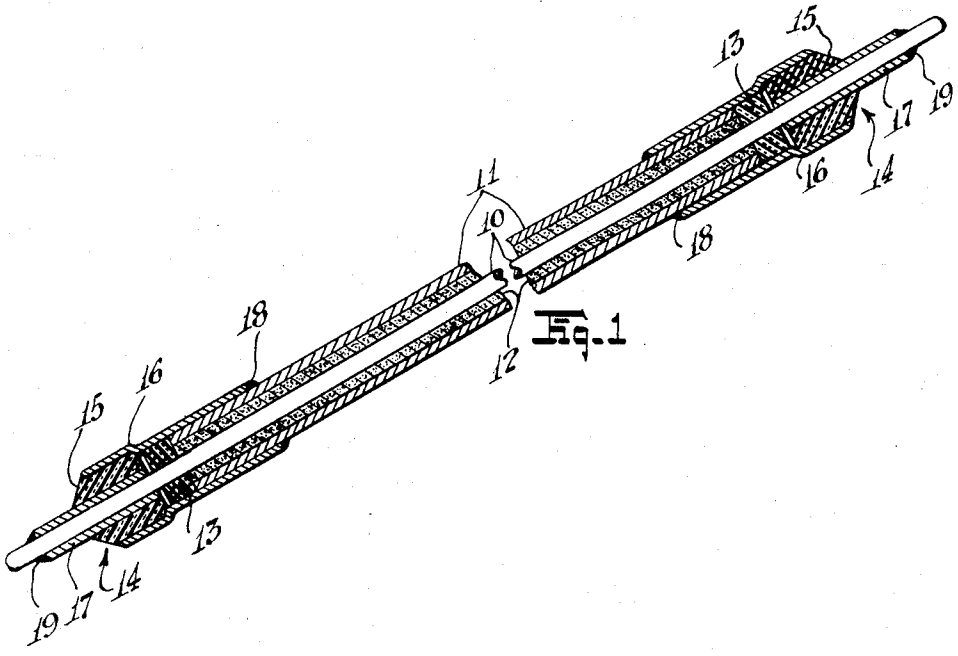


Fig. 1

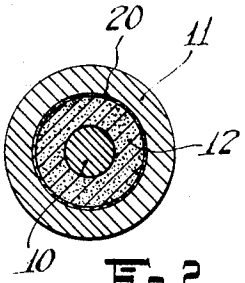


Fig. 2

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FIRE DETECTOR CABLE

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3 Claims. (Cl. 338—26)

This invention relates to novel temperature-responsive resistance cables which are adapted to give the cables higher operate points and faster response, the term "operate point" being herein employed to mean that temperature at which the resistance of a given length of cable falls to a given value, for example, when the resistance of a 50' length of cable falls to 100 ohms.

The cable to which my invention pertains is of the type described and claimed in the Kelly-Postal Patent 2,740,874, dated April 3, 1956, and in my pending application Serial No. 392,565, filed November 17, 1953 (now Patent No. 2,848,587, issued August 19, 1958). This type of cable comprises a metal sheath and an axial center wire with an intervening electronic semiconductor in a highly compacted form. The semiconductor is preferably of the P type including one or more of the oxides of manganese, copper and cobalt. When such semiconductor is heated it tends to release oxygent gas but the oxygen so released is precluded, because of the highly compacted condition of the semiconductor, from diffusing along the cable. As a result the oxygen is caused to recombine with the elemental portions from which it escapes when the cable is cooled, with the result that the cable maintains a stable operating characteristic.

A further feature in the foregoing cables which is instrumental in attaining a stable operating characteristic lies in providing the internal wall of the metal sheath with a heavy oxide layer effective to prevent further combination of released oxygen with the metal of the sheath during those periods of use when the cable is heated to firing temperatures. In order that such internal oxide layer will have a low resistance relative to that of the semiconductor—or, in other words, in order that the semiconductor will be controlling—the sheath has been heretofore made of metal alloys whose oxides have a low resistivity. For example, iron oxide is so highly conductive that oxides of alloys composed predominantly of iron will have such low resistivity. Thus, nickel-iron alloys composed of approximately 42% nickel and the remainder iron have a resistivity below that of the class of semiconductors aforementioned notwithstanding the presence of the more highly resistive oxide of nickel. On the other hand, a sheath of substantially all nickel or one of an alloy containing a substantial amount of chromium with or without nickel will have oxides which are relatively highly resistive, due to the high resistivity of chromium oxide (Cr_2O_3).

In many practical applications of fire detector cables it is desirable that the cables have higher operate points than can be obtained from control of the oxygen content of the semiconductors or of the physical dimensions of the cable. However, by the present invention such higher operate points are obtained by deliberately using a sheath material whose oxide has a relatively high resistivity. Examples of such sheath materials are pure nickel abovementioned, and alloys containing chromium such as Inconel containing approximately 75% nickel, 18% chromium and the remainder iron; stainless steel 446 containing 27% chromium and the remainder iron; and stainless steel 347 containing 18% chromium, 8% nickel, a small amount of columbium and the remainder iron.

Objects of my invention are therefore to provide fire detector cables with higher operate points and faster response by constructing the cables with a thin internal oxide film on the metal sheath adapted to contribute substantially to the resistivity of the cable, and a further object is to provide such cables with a spacing medium between the center wire and sheath comprising a semiconductive oxide having initially a controlled amount of excess oxygen for oxidizing the internal wall of the sheath to form such highly resistive oxide film when the cable is subjected to an initial stabilizing heat-treating operation.

In the description of my invention reference is had to the accompanying drawings, of which:

Figure 1 is a fractional cross sectional view of a cable according to my invention taken along the longitudinal axis thereof; and

Figure 2 is a transverse section to enlarged scale taken on the line 2—2 of Figure 1.

The fire detector cable shown in the accompanying figures comprises a central metal wire **10** constituting the electrode of the cable, a spaced surrounding metal sheath **11** constituting a second electrode, and an intervening electronic semiconductive metal oxide **12** disposed between the electrodes along the length of the cable and preferably of the P type such as of one or more of the oxides aforementioned. The semiconductive oxide is packed into the cable under great pressure as by swaging the sheath to a reduced diameter after the oxide is loaded into the sheath so as not only to assure positive electrical contact between the oxide and electrodes but also to preclude any possible diffusion of released oxygen from the oxide along the cable when any portion of the cable is heated to a firing temperature. The semiconductive oxide comprises preferably the sole spacing medium between the center wire and sheath except for the provision of ceramic beads **13** at the ends of the cable. The ends are preferably closed by hermetic seals **14** each comprising a glass bead **15** fused to outer and inner tubing sections **16** and **17**. These tubing sections are telescoped onto the sheath and center wire respectively and the ends thereof are secured to the ends of the sheath and wire by silver soldering at **18** and **19** respectively.

The method of fabricating the cable may for the present invention be the same as disclosed in the patent and application aforementioned. Briefly, a semiconductive oxide, say for example manganese oxide containing excess oxygen—i.e., a non-stoichiometric form of such oxide between manganous oxide (MnO) and manganese dioxide (MnO_2)—is mixed with an extruding lubricant such as Veegum (described in the Kelly et al. patent) and with about 10% by weight of water and is then extruded under great pressure onto the center wire. This extrusion is then dried in air for about 24 hours and is then passed through an extrusion furnace for about 15 minutes at about 1500° F. in an inert atmosphere such as nitrogen. Next the extrusion is threaded into a clean metal sheath which is made only slightly oversize to receive the extrusion without difficulty. The sheath is then swaged progressively to about two-thirds of its original diameter so as to compact the manganese oxide under great pressure.

The swaged cable is then heat treated at about 1000° C. for 15 to 20 minutes in a reducing atmosphere such as of carbon monoxide and is then sealed at its ends to complete its construction. In this final heat treatment the excess oxygen in the manganese oxide is released and combined with the internal wall of the sheath to a thickness representing a substantially stable condition of oxi-

dation whereat substantially no further oxidation will take place in the practical use of the cable.

In the Kelly et al. patent and in my pending application aforementioned the sheath has preferably been made of nickel-iron alloy containing about 42% nickel and the remainder iron because such alloy has not only corrosion resistance at flame temperature, durability and desired thermal coefficient of expansion, but also because the oxide of such alloy has such low resistivity relative to that of the semiconductive oxide that the latter is controlling as far as the temperature resistance characteristic of the cable is concerned. For instance, a 50' length of cable using a sheath having .070" outside diameter and .011" wall thickness, a center wire of .020" diameter and an intervening layer of manganese oxide of .012" thickness will have an operate resistance of 100 ohms at about 700° F. when the sheath is made of nickel-iron alloy and the manganese oxide is in its most reduced manganous form, it being understood that the resistivity of the cable is at its highest when the oxygen contained in the oxide is at its minimum. However, it is desired in certain applications that the cable be heated to a still higher temperature before its resistance falls to a 100 ohm value. I have found that such higher operate point can be attained simply by making the sheath of a metal or alloy whose oxide has a high resistivity relative to that of the semiconductive oxide, as aforementioned. When a cable is fabricated in the same manner as above described but with a metal sheath of Inconel, for example, a chromium oxide film **20** is formed on the inner surface of the sheath during the final heat treatment of the cable to raise the operate point to 900° F. The other metals aforementioned such as pure nickel and the stainless steels 446 and 347 will act similarly. Since the predominating resistance in these cables is provided by the thin oxide film on the metal sheath, the present cables are very fast in their response—which is a great advantage in all fire detecting applications.

It will be understood that the center wire may also be of a material whose oxide has a high resistivity so that the oxide layer thereon will likewise contribute to the resistance of the cable. Also, it will be understood that the entire metal of the sheath and center wire need not be of such material within the spirit of my invention so long as the internal wall of the sheath and the outer wall of the center wire are of such material. Also, although I preferably oxidize the sheath and center wire by oxygen from the semiconductor by heating the cable to a stabilizing firing temperature—a temperature at least as high or higher than that at which the cable is operated in practice—and for a sufficient period to form a sufficient oxide layer that will effectively seal the remaining metal of the sheath from further oxidation during use, the sheath and/or center wire may be first oxidized before the cable is assembled within the broader aspects of my invention.

The embodiments of my invention herein particularly shown and described are intended to be illustrative and not necessarily limitative of my invention since the same are subject to changes and modifications without departure from the scope of my invention, which I endeavor to express according to the following claims.

I claim:

1. A resistance-type temperature-responsive cable comprising a metal sheath, a center wire, an intervening temperature-responsive resistance material selected from the group consisting of the oxides of cobalt, manganese and copper, said resistance material having a negative temperature-responsive characteristic such that it is essentially an insulator at low temperatures and a conductor at flame temperature, and an adherent metal oxide layer on the internal wall of said sheath in intimate electrical contact with said temperature-responsive material and having also a negative temperature-responsive characteristic, said sheath being of a metal selected from the group consisting of substantially pure nickel and chromium alloys whose oxides have a resistivity substantially higher than that of said temperature-responsive material.

2. A resistance-type temperature-responsive cable adapted to have a predetermined resistance at a given temperature, comprising a metal sheath, a center wire, a temperature-responsive oxidic semiconductor of the P type selected from the group consisting of the oxides of cobalt, manganese and copper and interposed between said center wire and sheath, said semiconductor having an excess oxygen content when the cable is assembled, said sheath being of a metal of substantially pure nickel whose oxides have a high resistivity relative to that of said semiconductor, and the internal surface layer of said sheath being an oxide of the sheath material, said oxide being formed by excess oxygen released from said semiconductor when said cable is heated to a firing temperature.

3. A resistance-type temperature-responsive cable comprising a metal sheath, a center wire, and an oxidic semiconductor interposed between said center wire and sheath having a negative temperature coefficient of resistance, said semiconductor being selected from the group consisting of the oxides of manganese, cobalt and copper, said sheath being of a metal selected from the group consisting of essentially pure nickel and chromium alloys, said sheath having an internal surface layer of an oxide of the sheath material held in electrical contact with the semiconductor by compressive force of the sheath on the semiconductor, and said internal oxide layer having also a negative temperature coefficient of resistance and providing the major resistance between said sheath and center wire.

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