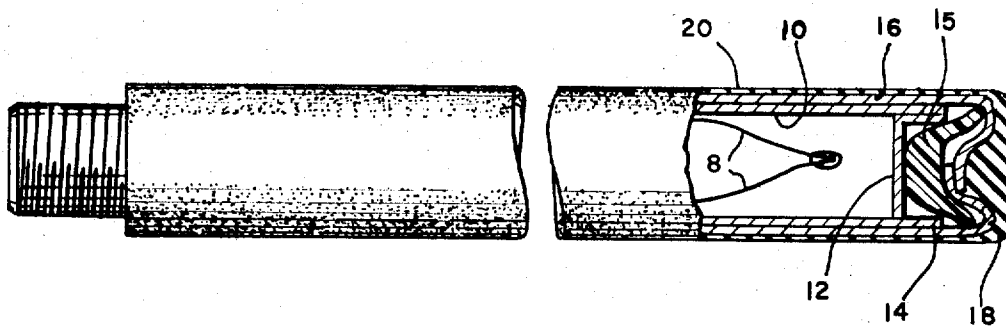


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PROTECTIVE TUBE FOR ELECTRICAL ELEMENTS
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3,560,282 PROTECTIVE TUBE FOR ELECTRICAL ELEMENTS AND ITS METHOD OF MANUFACTURE

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ABSTRACT OF THE DISCLOSURE

Disclosed herein is a protective tube for a thermocouple comprising a non-metallic mat of high temperature-resistant material rolled to form a tube with the mat impregnated with a sulfate binder solution and coated with a thermo insulating material. A supporting conduit may be used to provide physical support for the rolled mat.

BACKGROUND OF THE INVENTION

Thermocouples, which are used to indicate the temperatures of molten metal, must be shielded in order to protect the thermocouple elements while they are immersed in the molten metal. Protective tubes of high cost materials have been used; however, these tubes are fragile and/or the abrasive wash action of aluminum and other non-ferrous metals in melt operations tends to destroy the tube at a rate that makes them uneconomical to use. Plain cast iron tubes have been resorted to due to the relatively fast destruction of the special protective tubes. These tubes are inexpensive but require frequent replacement.

SUMMARY OF THE INVENTION

This invention relates to an improved high temperature protective tube for a thermocouple or other high temperature operating device. The tube includes a non-metallic mat which has been impregnated with a sulfate solution and dried to stiffen the mat so that it can be rolled to a tubular form without unravelling. The mat is wrapped around the outer surface of a supporting structure which may be in the form of a steel conduit with a part of the mat extending beyond one end of the conduit. The mat is impregnated with a sulfate solution with an inorganic filler, such as kaolin, added to form a binder. The sulfate-binder solution is dried and increases the temperature resistance of the mat and when desirable bonds the mat to the supporting structure. The sulfate-binder solution makes it possible to use an E grade fiber glass rather than a special high temperature of S grade fiber glass.

The end of the rolled mat extending beyond the conduit has to be closed in order to protect any electrical elements in the inside of the tube. It has been found that where special plugs are used to close the end of the supporting conduit, they tend to leak due to the difference of thermal coefficient of expansion. To prevent such leaks the material used for the non-metallic mat is also used to make a plug to close one end of the conduit and thereby prevent leaks which might result from variations in the thermal coefficient of expansion when using special plugs for sealing the end of the tube.

Since the non-metallic mat and the metal supporting tube, when used, have different temperature characteristics, the cool down rate of the non-metallic mat had to be reduced in order to prevent fracture due to thermal shock on withdrawal of the tube from the molten metal. A coating of thermo insulating material is applied to the outer surface of the sulfate impregnated non-metallic mat to insulate the mat and retard cool down. Since the sulfate has a tendency to precipitate the heat insulating

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materials, the surface of the sulfate impregnated mat is neutralized prior to coating with the insulating material. This type of protective tube has been found to be of sufficient strength to be used for high temperature use and to withstand accidental impact.

Other objects and advantages of the present invention will be apparent from the following detailed description when read in connection with the accompanying drawing in which the single figure is a side view partly in section of the protective tube.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Although the disclosure hereof is detailed and exact to enable those skilled in the art to practice the invention, the physical embodiments herein disclosed merely exemplify the invention which may be embodied in other specific structure. The scope of the invention is defined in the claims appended hereto.

Referring to the figure in the drawing, the protective tube includes a supporting structure 10 such as a thin walled steel conduit of sufficient length to enclose a pair of thermocouple wires or elements 8. The supporting structure or conduit may be of any length required for a particular application and may have any outer configuration such as square, triangular, etc. In the disclosed embodiment, a tubular conduit having a wall thickness of approximately $\frac{3}{16}$ inch is shown. If the supporting structure is to be removed from the mat, it should be made of a material that will not adhere to the mat during the steps required to form the tube.

The conduit is covered with a non-metallic mat 16 of fiber glass, crocidilite asbestos or a vitreous woven fiber such as Refrasil made by Hitco of California, which has been immersed in a sulfate solution and dried with the end 18 of the mat extending beyond the end of the conduit. The mat is then impregnated with a sulfate-binder solution and allowed to dry until it is tacky.

A metal cap 12 is provided in the end of the conduit and a disc 15 formed of the same non-metallic material that is used to cover the conduit is inserted in the extended end 18 of the fiber glass. The mat is then folded over or crimped to the disc to close the end of the tube. Additional coatings of sulfate-binder solution may be added if the supporting structure is to be removed.

A coating or layer 20 of a heat insulating solution such as a silicate cement is applied to the outer surface of the fiber glass to reduce the rate of cool down of the fiber glass. This coating should be approximately $\frac{1}{32}$ — $\frac{1}{16}$ inch thick but can be varied as required. If the tube is to be used for extremely high temperature operations, the thickness of the heat insulating coating should be increased.

The woven mat may be a fiber glass material made from an E grade fiber glass which is used for electrical application. E grade being a classification of fiber glass sold by the Owens-Corning Glass Company. This type of fiber glass is considered to be a low temperature material and, therefore, not as expensive as a high temperature fiber glass such as the S grade. A fiber glass mat of randomly arranged fiber glass could also be used. Other high temperature materials which could be used are crocidilite asbestos, Refrasil and Fiberfrax made by the Carborundum Company. All of these materials are capable of being impregnated with a sulfate binder solution.

The process or method for manufacturing the protective tube shown in the figure in the drawing includes the following steps:

(a) A strip of woven fiber glass made from E grade fiber glass is initially passed through a solution containing 5 to 50 percent aluminum sulfate (Al_2SO_4) and dried.

The fiber glass is heated at a temperature sufficient to dry the solution. B staging of the sulfate solution provides sufficient rigidity in the mat to prevent unravelling from occurring when the mat is cut.

(b) The dried mat is cut to the required dimensions so that it can be wrapped around the thin walled steel conduit 10 with the end 18 of the mat extending beyond the end 14 of the conduit. The disc 15 is also cut from the strip of fiber glass at this time.

(c) The cut strip of dried fiber glass is impregnated with a sulfate-binder solution consisting of aluminum sulfate (Al_2SO_4), kaolin and water. The range of the materials used for this impregnant is believed to be critical to the success of the protective tube. Optimum results were obtained with a solution (by weight) containing 62½ percent Al_2SO_4 and 37½ percent kaolin diluted to 200 percent with water. The amount of water can be varied to effect a viscosity sufficient to allow for complete impregnation of the woven fiber glass. The impregnated fiber glass material used to form the disc 15 was also impregnated with the same sulfate solution and dried prior to insertion in the end 18 of the mat. The ratio of Al_2SO_4 to kaolin may be varied to 60 to 65 percent Al_2SO_4 to 40 to 35 percent kaolin. Tests have indicated that if the aluminum sulfate is increased to 70 percent or more or is reduced below 58 percent the heat resistance of the fiber glass drops off considerably. Other inorganic fillers such as talc may be used in place of the kaolin.

(d) The impregnated fiber glass, while still wet, is wrapped around the conduit with the end 18 of the fiber glass extending beyond the end 14 of the conduit. The sulfate impregnated fiber glass disc 15 is inserted into the extended end of the rolled mat in the end 14 of the conduit in abutting engagement with the metal cap 12. The fiber glass, after being wrapped on the conduit, is air dried for approximately four hours to allow the sulfate-binder solution to dry to a tacky condition. The end 18 of the fiber glass is then crimped over the disc 15 and will adhere to the disc due to the tacky condition of the fiber glass.

(f) The rolled tube is placed in an oven at a temperature of 200° F. and is left in the oven for approximately one hour. The temperature is then raised to 275° F. and drying continued for about two hours.

(g) The tube is removed from the oven and is washed with warm water to remove excess binder from the surface of the fiber glass.

(h) Since the sulfate binder is an acid material which precipitates silicates, the surface of the tube must be neutralized prior to coating the outside of the tube with

the thermo insulating material. This is done by wiping or dipping the tube into a solution of 20 percent caustic soda to neutralize the sulfate binder on the outside surface of the woven fiber glass. Soda, ash or any other alkalis can be used to neutralize the mat.

(i) The thermo insulating material such as silicate cement 20 is then applied to the outer coating of the tube and dried. While various silicates may be used, in the embodiment described, a silicate cement called Atmoset formulated by the A & P Green Company was used. Additional coatings of the silicate cement can then be added by merely brushing them onto the surface of the tube until the desired thickness is obtained. A thickness of approximately ¼ inch is considered sufficient for this tube. A high temperature insulating coating material such as a Cera-Kote made by Johns-Manville could also be used.

What is claimed is:

1. A protective tube for a thermocouple comprising a hollow tubular mat of high temperature resistant fiber glass material closed at one end, said material being impregnated with an aluminum sulfate containing binder, the outer surface of said mat being neutralized with a solution containing caustic soda, and a layer of thermo insulating silicate material coated on the outside surface and the closed end of said mat.
2. A protective tube according to claim 1 including a thin walled steel supporting conduit within said hollow tubular mat.
3. A protective tube according to claim 1 wherein said sulfate binder includes, by weight, 60 to 65 percent aluminum sulfate and 35 to 40 percent inorganic filler.
4. A protective tube according to claim 2 including a disc of high temperature material formed from the same material as the tubular mat closing the said one end of the conduit.

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