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METHOD AND APPARATUS FOR PROLONGING LIFE OF THERMOCOUPLES

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FIG. 1

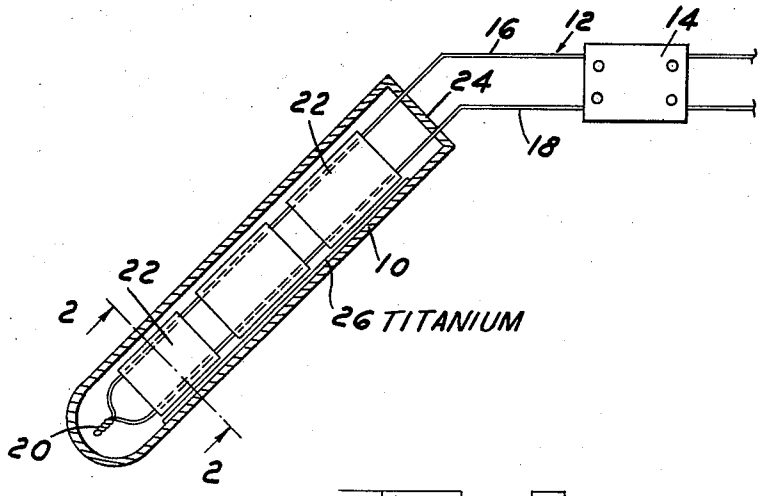
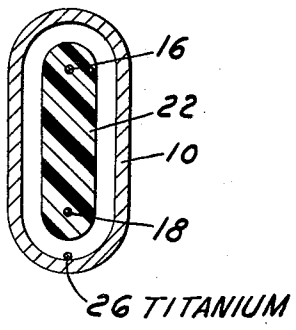


FIG. 2



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METHOD AND APPARATUS FOR PROLONGING LIFE OF THERMOCOUPLES

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11 Claims. (Cl. 136—4)

This invention relates to thermocouples and more particularly to a method and apparatus for prolonging the life of Chromel-Alumel thermocouples.

One of the most commonly used types of thermocouples are those made of wire known commercially as Chromel-Alumel. Chromel is an alloy having a nominal composition of 90% nickel and 10% chromium. Alumel is an alloy having a nominal composition of 2% aluminum, 3% manganese, 1% silicon and the balance nickel.

Thermocouples made of Chromel-Alumel are quite stable in clean oxidizing atmospheres such as normal atmospheric air. However, good thermocouple practice requires the use of a protection tube in liquids, corrosive gases or in locations where physical damage may occur due to rough handling.

A good protection tube closed at the exposed end would seem to guarantee maintenance of an accurate thermocouple under any set of conditions that would not destroy the tube, but, unfortunately, this has not always been true. One of the most common sources of trouble has been the residual foreign matter inside the tube which becomes corrosive when heated. One recommended practice to eliminate this trouble has been to burn out all tubes prior to use by soaking in a high temperature furnace. However, even when this precaution is taken, a serious problem still remains. In many cases where the protection tube has a substantially high length-to-diameter ratio, a very appreciable error occurs. This error is in the nature of a decrease in the thermal E.M.F. of the Chromel alloy in the critical temperature range of approximately 1500° to 1900° F.

It is an object of this invention to provide a method and an apparatus for eliminating the error usually encountered in using Chromel-Alumel thermocouples enclosed in protection tubes. Accordingly, it is a further object of the invention to substantially increase the life of the Chromel-Alumel thermocouples.

Heretofore, this error in the nature of a decrease in the E.M.F. produced when thermocouples of the type described have been used in protection tubes has been attributed to diffusion of hydrogen from the furnace atmosphere through the tube wall to create alternate oxidizing and reducing conditions. Tests have shown, however, that although diffusion of hydrogen may contribute to this error, it is not the real source of the difficulty.

Numerous tests have been conducted which define the basic problem as one involving the preferential oxidation of the chromium from the Chromel wire in the low oxygen pressure atmosphere produced in a closely confined tube. It has been discovered that in an atmosphere where the oxygen content is below about 20%, the chromium oxidizes in preference to the nickel and this oxidation is not merely on the surface but diffuses into the wire along the grain boundaries. Thus, after prolonged oxidation, the composition of the wire changes so that actually two phases are present, one phase consisting of the high nickel alloy and the other of chromium oxide particles along the grain boundaries. Thus, since the composition is no

longer 90% nickel and 10% chromium, and since when the chromium content drops to less than 10%, the E.M.F. also drops rapidly, a serious error is introduced.

In view of these facts, it is obvious that this problem is of particular importance when the thermocouple is used with an inadequate air supply (as in a tube with the cold end partially or totally closed or in a long narrow tube especially if insulators fill most of the tube). With an inadequate supply of air, the oxygen is depleted by normal oxidation of the thermocouple wire and the inner surface of the protection tube. Under these conditions, the oxygen reaches a critical low partial pressure fairly rapidly and then inter-granular oxidation of the Chromel wire begins. Tests have shown that when the tube is completely sealed, the oxidizing action can be supported by the oxygen contained in the tube or by the oxide finish on the wires.

Having formulated the above theory of the preferential oxidation of the chromium from the Chromel wire in protection tubes where there is an inadequate supply of air, I found that this very troublesome problem could be substantially eliminated if all the oxygen is excluded from the tube such as by evacuation or purging; and, further, if a "getter," a material having a stronger affinity to oxygen than the chromium, is incorporated in the protection tube. Titanium, for example, has a stronger affinity for oxygen than the chromium and very good results have been attained by using a strip of titanium in the protection tube.

A thermocouple assembly in accordance with the present invention is illustrated in the drawings wherein Fig. 1 shows the general arrangement of the thermocouple within the protection tube, and Fig. 2 is a sectional view along the lines 2—2 in Fig. 1.

In Fig. 1, the protection tube which may be of a non-oxidizing metal such as Inconel (15% chromium—7% iron—balance nickel) or stainless steel or a ceramic protection tube is indicated at **10**. The thermocouple **12** connected to the terminal block **14** comprises a Chromel wire **16** and an Alumel wire **18** welded together at the junction **20**. The wires **16** and **18** are threaded through insulators **22** and are sealed in tube **10** in any suitable manner by means of air tight sealing member **24**. The "getter" **26** is in the form of a strip of titanium or the like in the form of wire, ribbon, etc. that provides an extended surface very susceptible to oxidation. With the arrangement discussed herein, it has been found that the life of Chromel-Alumel thermocouples can be prolonged almost indefinitely. Best results have been obtained when the tube is evacuated and hermetically sealed and a strip of "getter" material, preferably titanium, is placed in the tube.

I claim:

1. The method of prolonging the life of a thermocouple one element of which comprises a nickel-chromium alloy which comprises sealing the thermocouple in a protection tube formed of a relatively non-oxidizing material and incorporating in the tube a quantity of material that oxidizes more readily than chromium.

2. The method of prolonging the life of a thermocouple one element of which comprises a nickel-chromium alloy which comprises sealing the thermocouple in a protection tube formed of a relatively non-oxidizing material and maintaining the atmosphere within the tube substantially free of oxygen by incorporating in the tube a quantity of material that oxidizes a more readily than chromium.

3. The method of prolonging the life of a thermocouple one element of which comprises a nickel-chromium alloy which comprises sealing the thermocouple in a protection tube formed of a relatively non-oxidizing material and preventing the oxygen within the tube from

reacting with the chromium in the thermocouple element by incorporating in the tube a quantity of material that oxidizes more readily than chromium.

4. The method of prolonging the life of a thermocouple one element of which comprises a nickel-chromium alloy which comprises sealing the thermocouple in a protection tube having a relatively non-oxidizing inner surface and incorporating in the tube a strip of titanium.

5. The method of prolonging the life of a thermocouple one element of which comprises a nickel-chromium alloy which comprises arranging the thermocouple within a protection tube formed of a relatively non-oxidizing material, removing the oxygen from the atmosphere within the tube, incorporating in the tube a quantity of material that oxidizes more readily than chromium and thereafter hermetically sealing the tube.

6. The method called for in claim 5 wherein the oxygen is removed from the tube by evacuating the tube.

7. The method called for in claim 5 wherein the oxygen is removed from the tube by purging the tube with an inert gas.

8. A thermocouple assembly comprising a thermocouple sealed within a protection tube formed of a relatively non-oxidizing material, said thermocouple being of the type wherein one of the elements comprises a nickel-chromium alloy, said tube also containing a quantity of material that oxidizes more readily than chromium.

9. A thermocouple assembly comprising a thermocouple sealed within a protection tube formed of a relatively non-oxidizing material, said thermocouple being of the type wherein one of the elements comprises a nickel-chromium alloy, said tube also containing a strip of titanium.

10. A thermocouple assembly comprising a thermocouple hermetically sealed within a protection tube formed of a relatively non-oxidizing material from which substantially all the oxygen has been removed, said thermocouple being of the type wherein one of the elements comprises a nickel-chromium alloy, said tube also containing a quantity of material that oxidizes more readily than chromium.

11. A thermocouple assembly comprising a thermocouple hermetically sealed within an evacuated protection tube formed of a relatively non-oxidizing material, said thermocouple being of the type wherein one of the elements comprises a nickel-chromium alloy, said tube also containing a strip of titanium.

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