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[54] **THERMOCOUPLE WITH NICKEL-SILICON-MAGNESIUM ALLOY NEGATIVE ELEMENT**

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[52] **U.S. Cl.** **136/239**, 136/236, 75/170

[51] **Int. Cl.** **H01v 1/22**

[58] **Field of Search** 136/236, 239; 75/170

[56] **References Cited**

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[57] **ABSTRACT**

A nickel-base alloy, useful as a negative thermoelement, is disclosed. The alloy consists essentially of from about 3.25 to about 5.0 percent by weight of silicon and from about 0.03 to about 0.25 percent by weight of magnesium and the balance nickel. The new alloy is more oxidation resistant and has a greater EMF stability than existing type K negative thermoelements.

5 Claims, No Drawings

THERMOCOUPLE WITH NICKEL-SILICON-MAGNESIUM ALLOY NEGATIVE ELEMENT

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of Ser. No. 173,671, filed Aug. 20, 1971 and assigned to the assignee of the present invention. Original assignment recorded on Aug. 20, 1971, Reel 2775, Frame 135. BACKGROUND OF THE INVENTION

This invention relates to nickel-base alloys. More particularly, it is related to nickel-base alloy having a superior oxidation resistance and EMF stability under long time periods of usage than existing type K negative thermoelements.

Nickel-base alloys have been in use as thermoelements since the early part of this century. One of the commonly used thermocouples is the type K thermocouple (designated by the Instrument Society of America). The positive type K thermoelement is a nickel base alloy containing 9.25 Cr, 0.4 Si, balance essentially nickel. The negative type K thermoelement is a nickel base alloy containing 2A1, 2.5 Mn, 1 Si, with small amounts of Fe and Co. There are numerous commercial suppliers of type K thermocouples.

The type K thermocouple is recommended to be used in air atmosphere. At high temperatures in air the negative type K thermoelement is the weaker link of the couple. It fails much sooner than the positive type K thermoelement because of its poorer oxidation resistance. In addition, a much larger portion of the EMF drift of the couple as a whole is attributed to the EMF change of the negative thermoelement. As a result, there is a need for a new negative thermoelement with improved oxidation resistance and EMF stability.

It is believed, therefore, that a new alloy useful as a negative thermoelement which has excellent oxidation resistance and EMF stability is an advancement in the art.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide a new alloy which is oxidation resistant.

It is a further object of this invention to provide an alloy having excellent EMF stability.

It is a further object of this invention to provide a negative thermoelement alloy.

These and other objects are achieved in one aspect of this invention by an alloy consisting essentially of from about 3.25 percent to about 5.0 percent by weight of silicon, from about 0.03 percent to about 0.25 percent by weight of magnesium and the balance nickel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For a better understanding of the present invention together with other and further objects, advantages, and capabilities thereof, reference is made to the following specification and appended claims.

The alloys of this invention have excellent oxidation resistance. Although the EMF of the alloys are more negative than the prior art negative type K thermoelements and, when used with conventional positive type K thermoelements, the resulting couple does not match the reference tables now in use, the trend is away from manual matching because the installation of many computer controlled processes. Thus, EMF stability of the thermocouple has become more important than the actual EMF at a particular temperature. It has been found that the alloys of this invention change very little even after being exposed in air from over 21,000 hours at 1,800° F. When compared to the negative thermoelement now in use, the error in a thermocouple is greatly reduced.

Addition of silicon to nickel is known to improve oxidation resistance over the thermoelements now in use, hence longer life; however, the alloys of this invention containing magnesium exhibit better EMF stability than alloys without the magnesium.

The alloys of this invention consist essentially of from about 3.5 to about 5 percent by weight of silicon and from about 0.03 percent to about 0.25 percent by weight of magnesium and the balance nickel. Preferred are alloys containing from about 3.75 to about 4.25 percent by weight of silicon and from about 0.10 to about 0.20 magnesium with balance of nickel. Especially preferred is an alloy containing 4% silicon, 0.15 percent magnesium and balance nickel.

EXAMPLE 1

The alloy of this invention is melted and processed to wire using existing manufacturing procedures. The alloy is made and drawn to 0.128 inch diameter. Its performance is demonstrated by a long-term stability test. The temperature is 1,800° F. The atmosphere is air. The total time at temperature exceeds 21,000 hours.

In addition to the Ni/4Si 0.15Mg alloy, a conventional positive and negative type K thermoelement, plus a Ni/4Si alloy without any Mg addition, all in the form of 0.128 inch diameter wire, are tested simultaneously for comparison. The results are as follows:

A. Individual Thermoelement

	EMF at 1800° F, vs. Pt MV		EMF
	Initial	After 21,196 Hr.	in MV
K (+) *	+32.098	+31.974	+0.124
K (−) **	−8.643	−9.068	−0.425
Ni/4Si	−10.208	−10.487	−0.279
Ni/4Si/0.15Mg	−10.092	−10.135	−0.043

* positive type K thermoelement
** negative type K thermoelement

B. Thermocouple

	After 21,196 Hrs. EMF in MV	Temp. in °F[1]
1 K (+) vs. K (−)	+0.549	+25
2 K (+) vs. Ni/4Si	+0.403	+18
3 K (+) vs. Ni/4Si/0.15Mg	+0.167	+7

(1) For a type K couple
[1]the thermoelectric power at 1800° F is 0.022 MV per °F and the other two thermocouples (2 and 3) the thermoelectric power is 0.023 MV per °F.

The above long term atest at a high temperature of 1,800° F decisively demonstrates that the Ni/4Si/0.15 Mg alloy is far superior to the others to both the conventional type K thermoelement and to a 4 percent silicon-nickel alloy.

The beneficial effect in EMF stability is attributed to the addition of the proper amount of magnesium to the Ni/4Si alloy base.

The range of magnesium content is from 0.03 to about 0.25 percent Mg, with the preferred amount of from 0.10 to 0.20 percent Mg. The presence of Mg in nickel in trace amounts of 0.01 percent or below does not have any beneficial effect on EMF stability and the presence of Mg above 0.25 percent impairs the workability of the alloy.

The range of silicon content is from 3.25 to 5.00 percent. A minimum of about 3.25 percent is needed for oxidation resistance. Above about 5 percent Si, the workability of the alloy is impaired. Preferred is from about 3.75 to about 4.25 percent silicon.

While there has been shown and described what is at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A thermocouple consisting essentially of a positive thermoelement alloy consisting essentially of about 9.25 percent chromium, 0.4 percent silicon and balance nickel and a negative thermoelement alloy consisting essentially of from about 3.25 to about 5.0 percent by weight of silicon and from about 0.03 to about 0.25 percent by weight of magnesium and balance nickel.

2. A thermocouple according to claim 1 wherein in said negative thermoelement alloy said silicon is from about 3.75 to about 4.25 percent by weight.

3. A thermocouple according to claim 1 wherein in said negative thermoelement alloy said magnesium is from about 0.10 to about 0.20 percent by weight.

4. A thermocouple according to claim 2 wherein in said negative thermoelement alloy said magnesium is from about 0.10 to about 0.20 percent by weight.

5. A thermocouple according to claim 4 wherein in said negative thermoelement alloy said silicon is about 4 percent by weight and said magnesium is about 0.15 percent by weight.

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