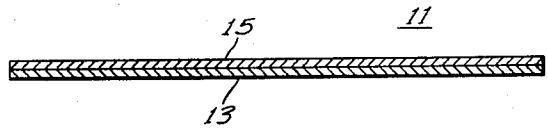
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BIMETAL THERMOSTAT

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## BIMETAL THERMOSTAT

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4 Claims. (Cl. 297—15)

My invention relates to temperature-responsive devices and more particularly to bimetal thermostats.

It is an object of my invention to provide a bimetal thermostat which will have optimum operating characteristics not only as to deflection under changes of temperature, but also as to the maximum temperature to which the device can be safely subjected.

Another object of my invention is to provide a bimetal element that shall have good manufacturing characteristics, that is, one which may be easily cold rolled to size without acquiring appreciable curvature, twist or excessive distortion from a plane surface at room temperature.

In practicing my invention I provide more particularly two iron alloys which may be welded or otherwise united with each other, the element having the high temperature coefficient of expansion containing from 26% to 7% of nickel, from 2% to 6% of manganese, from 1/10% to 10% of chromium and from .05% to .25% of carbon with traces of cobalt. The low expansion component is an iron alloy including from 35% to 12% of nickel, from .10% to 35% of cobalt, from .10% to 1.0% manganese, from .10% to 3% of chromium, molybdenum, tungsten or titanium either single or in combination and from .05% to .25% of carbon.

The single figure of the drawing illustrates one form of device which may embody the invention, namely, a bimetal strip 11 having a high-expansion component 13 and a low-expansion component 15.

In my earlier Patent 1,671,490 I have disclosed and claimed a high-expansion component including 10% of nickel and 10% of manganese in combination with iron and other metals in minor quantities. I have found, as the result of further development work on bimetals of this general composition, that a 10% nickel, 10% manganese iron alloy has rather a poor resistance to corrosion, as well as somewhat unsatisfactory rolling characteristics.

I have found that the corrosion resistance is materially improved by an increase in the amount of nickel in the high-expansion component with an accompanying reduction in the amount of manganese present in the alloy.

I have also found that an alloy of the above-described general composition has somewhat objectionable cold rolling characteristics in that the bimetal takes on a cross curvature or other permanent distortion because of the fact that the high expansion alloy is harder than the low-expansion alloy usually associated therewith, and also because the high-expansion alloy hardens more rapidly when being cold rolled. This disadvantage may be partially corrected without impairing the resistance to corrosion by substituting chromium for part of either the nickel or the manganese in the high-expansion alloy.

As a result of numerous experimental compositions and tests on the same I have found that the composition is governed quite closely by the following:

$$\%\text{nickel}+2.5(\%\text{manganese})+2(\%\text{chromium})+18(\%\text{carbon}) \quad \text{(Equation 1)}$$

should be between 32 to 36, while at the same time, the carbon content is appreciably less than .3% and preferably is .1%, the nickel content is less than 26% and above 7%, the chromium is under 10% and not less than .1%. As an example of a preferred composition for the high-expansion component meeting the above-named conditions I may mention an iron alloy containing 20% nickel, 4% chromium, 2% manganese and .1% carbon, with the remainder being principally iron, but including incidental elements normal in steel. A component of this kind has the desired properties of being less corrodible than previous bimetals of the same type and of having desirable cold rolling characteristics. Another substantially similar composition which I have found that is somewhat less expensive is an alloy of 10% nickel, 6% manganese, 4% chromium, .1% carbon, the remainder being iron and incidental elements normal in steel. These alloys are non-magnetic.

I prefer to combine such a high-expansion component with a low-expansion alloy containing nickel or nickel and cobalt, with the combined nickel and cobalt content lying between 34% and 55%, the major portion of the alloy being iron. Chromium, molybdenum, tungsten or titanium, either singly or in combination may be substituted for a part of the nickel content in order to obtain better working qualities and greater strength of the alloy at high temperatures. Although chromium is somewhat detrimental to the expansion properties of the low expansion component, its effect may be neutralized, at least in part, by an increase in the cobalt content by the amount that the nickel content is decreased when chromium, molybdenum, tungsten or titanium or combinations thereof are added.

I have found that the relation between the amount of chromium or its equivalents and nickel in the low expansion alloy may be set forth in the following equation:

$$\frac{\%\text{ Ni}+2.5(\%\text{ Mn})+2(\%\text{ Cr})+18(\%\text{ C})}{\%\text{ Fe}}=.50 \text{ to } .60 \quad \text{(Equation 2)}$$

A concurrent requirement is that, as stated above, the percentage of the nickel plus cobalt should be between 34% and 55%.

Table I gives a number of different compositions of a high-expansion component, these compositions meeting the requirements set forth above in Equation 1.

*Table I.—High-expansion component*

| | % Ni | % Co | % Mn | % Cr | % C | % Fe (approximately) |
|---|---|---|---|---|---|---|
| 1 | 26 | Traces | 2 | 0.1 | 0.1 | 71.8 |
| 2 | 23 | Traces | 3 | 1 | .1 | 72.9 |
| 3 | 20 | Traces | 2 | 4 | .1 | 73.9 |
| 4 | 15 | Traces | 4 | 4 | .1 | 76.9 |
| 5 | 10 | Traces | 6 | 4 | .1 | 79.9 |
| 6 | 7 | Traces | 6 | 5 | .1 | 81.9 |

Table II gives a number of compositions of a low-expansion component meeting the requirement of Equation 2 given above.

*Table II—Low-expansion component*

| | Mo, W, Ti or | | | | | |
|---|---|---|---|---|---|---|
| | % Ni | % Co | % Mn | % Cr | % C | % Fe (approximately) |
| 1 | 35. | 0.1 | 0.1 | 0.1 | 0.1 | 64.6 |
| 2 | 31.9 | 4.1 | .5 | .1 | .1 | 63.3 |
| 3 | 26. | 12.0 | .5 | 2.0 | .1 | 59.0 |
| 4 | 18.0 | 22.0 | .5 | 5.0 | .1 | 54.0 |
| 5 | 28.6 | 13.4 | .5 | .1 | .1 | 57.3 |
| 6 | 23.0 | 20.0 | .5 | 2.0 | .1 | 54.0 |
| 7 | 17.0 | 28.0 | .5 | 4.0 | .1 | 50.0 |
| 8 | 12.0 | 34.0 | .5 | 6.0 | .1 | 47.0 |

It may be noted that compositions 1 to 4, inclusive, in Table II will cooperate with any one of the alloys in Table I to give a maximum deflection of a bimetal element including them, at temperatures between zero to 100° C. while alloys 5 to 8, inclusive, of Table II when combined with any one of the high-expansion components in Table I will have a maximum deflection over a temperature range of 150° C. to 300° C. or even 400° C.

Various modifications may be made in the device embodying my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or are set forth in the appended claims.

I claim as my invention:

1. A thermostatic element comprising a pair of cooperating metallic members having different temperature coefficients of expansion, the high expansion member being an iron-nickel alloy including lesser quantities of manganese, chromium and carbon, the relation between the percentages of nickel, manganese, chromium and carbon being expressed by the formula

$$1\times\%\ \mathrm{Ni}+2.5\times\%\ \mathrm{Mn}+2\times\%\ \mathrm{Cr}+18\times\%\ \mathrm{C}$$

the value of which should lie between 32 and 36, the nickel content to be between 7% and 26%, the chromium content to be between 10% and .1% and the carbon content to be between .05% and .3%, and the low expansion member being an iron-nickel-cobalt-chromium alloy including minor quantities of manganese and carbon, the relation between the percentages of iron, nickel, manganese, chromium and carbon being expressed by the formula

$$\frac{1\times\%\ \mathrm{Ni}+2.5\times\%\ \mathrm{Mn}+2\times\%\ \mathrm{Cr}+18\times\%\ \mathrm{C}}{1\times\%\ \mathrm{Fe}}$$

the value of which should lie between .50 and .60 the combined percentage of nickel and cobalt being between 34 and 55.

2. A thermostatic element comprising a pair of cooperating metallic members having different temperature coefficients of expansion, the high expansion member being non-magnetic and having substantially the following composition,

| | Per cent. |
|---|---|
| Nickel | 26. to 7. |
| Manganese | 2. to 6. |
| Chromium | 0.1 to 5. |
| Cobalt | Traces |
| Carbon | 0.1 |
| Iron and impurities | Remainder |

and the low expansion member having substantially the following composition,

| | Per cent. |
|---|---|
| Nickel | 35. to 12.0 |
| Manganese | 0.1 to 1.0 |
| Chromium, tungsten, molybdenum or titanium | 0.1 to 8.0 |
| Cobalt | 0.1 to 35.0 |
| Carbon | 0.05 to 0.25 |
| Iron and impurities | Remainder |

3. A thermostatic element comprising a pair of cooperating metallic members having different temperature coefficients of expansion, the high expansion member having substantially the following composition,

| | Per cent. |
|---|---|
| Nickel | 20. |
| Manganese | 2. |
| Chromium | 4. |
| Carbon | 0.1 |
| Cobalt | Traces |
| Iron and impurities | Remainder |

and the low expansion member having substantially the following composition,

| | Per cent. |
|---|---|
| Nickel | 26.0 |
| Cobalt | 12.0 |
| Chromium, tungsten, molybdenum. titanium | 2.0 |
| Manganese | .5 |
| Carbon | .1 |
| Iron and impurities | Remainder |

4. A thermostatic element comprising a pair of cooperating metallic members having different temperature coefficients of expansion, the high expansion member having substantially the following composition,

| | Per cent. |
|---|---|
| Nickel | 7. |
| Manganese | 6. |
| Chromium | 5. |
| Carbon | .1 |
| Cobalt | Traces |
| Iron and impurities | Remainder |

and the low expansion member having substantially the following composition,

| | Per cent. |
|---|---|
| Nickel | 17.0 |
| Cobalt | 28.0 |
| Manganese | .5 |
| Chromium, tungsten, molybdenum. titanium | 4.0 |
| Carbon | .1 |
| Iron and impurities | Remainder |

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