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ELECTRICAL RESISTOR OF THERMOSTATIC LAMINATED METAL

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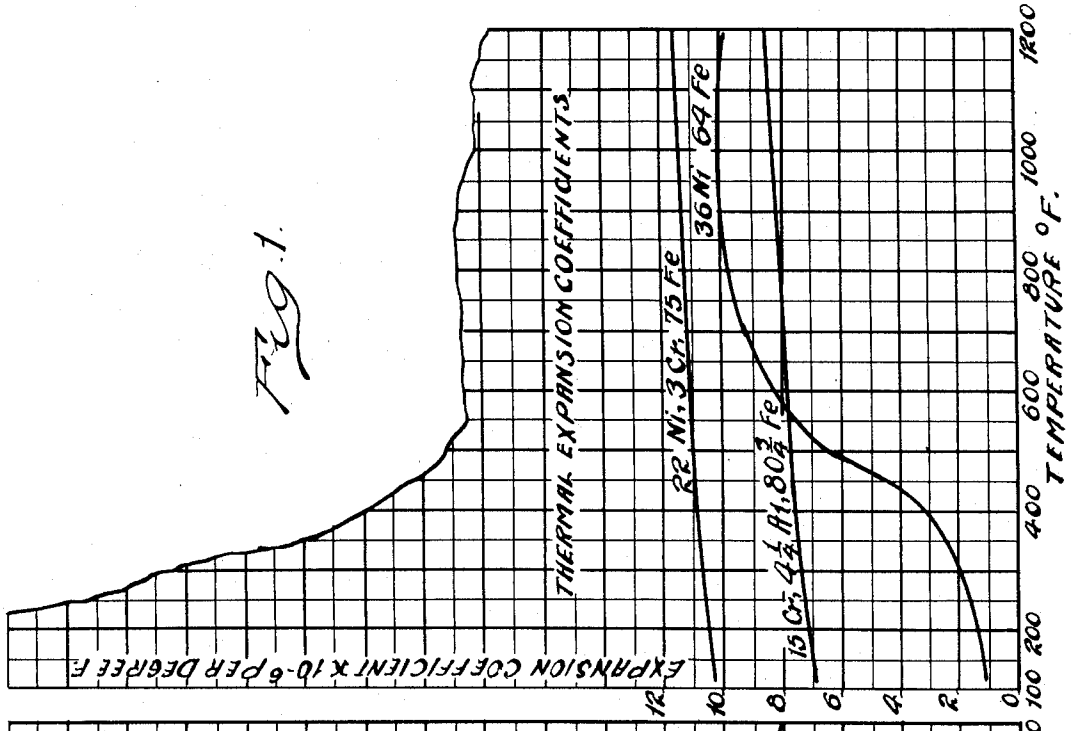


Fig. 1.

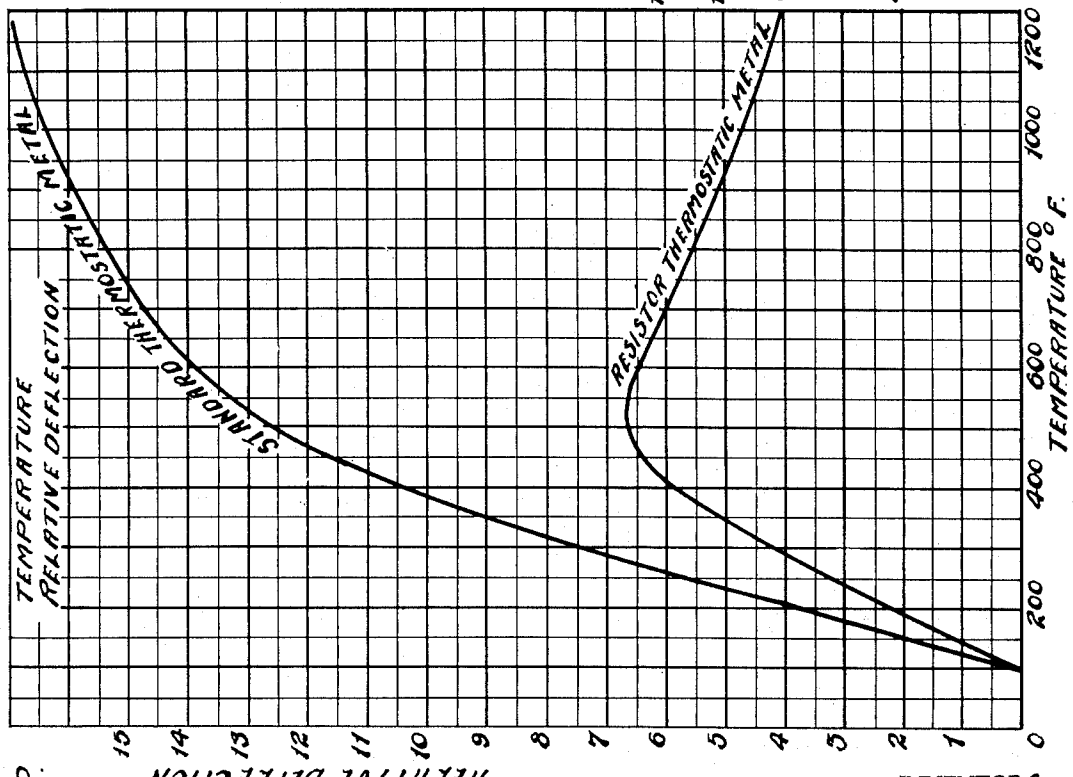


Fig. 2.

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ELECTRICAL RESISTOR OF THERMOSTATIC LAMINATED METAL

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10 Claims. (Cl. 297—15)

This invention relates to an electrical resistor of thermostatic laminated metal. More particularly the invention is concerned with an electrical resistor having a high electrical resistivity which is particularly useful for circuit breakers having a low amperage rating.

It is an object of this invention to produce an electrical resistor of laminated thermostatic metal having a lower thermal stress than other known resistors of laminated thermostatic metals at temperatures in the neighborhood of 500° F. and above.

It is an object of this invention to produce an electrical resistor of laminated thermostatic metal having a high modulus of elasticity, high electrical resistivity, and special thermal deflection properties which particularly characterize the greater utility for special purposes of the herein described resistor over other known laminated thermostatic metal resistors.

In the drawing:

Fig. 1 is a graph showing the thermal expansion coefficients of three alloys.

Fig. 2 is a graph showing the relative deflection of a standard or known laminated thermostatic metal and of the resistor laminated thermostatic metal which is the subject of this invention.

In fabricating the electrical resistor, which is the subject of this invention, it is proposed to make the low expanding side or lamina of any of the well known alloys used for this purpose, but the nickel-iron alloys, such as Invar, are preferred. The nickel content of the alloy forming the low expanding lamina can vary from 35% to 42% by weight with the balance iron. In Fig. 2 the thermal expansion coefficients of a 36% nickel, 64% iron alloy is shown.

The high expanding lamina comprises principally a chromium, aluminum, iron alloy wherein iron comprises the major constituent of the alloy. The chromium content of the alloy can vary within a range from about 10% to about 40% by weight. The aluminum content of the alloy can vary from about 3% to about 10% by weight. The balance of the alloy is iron. In some instances it is desirable to add manganese. Manganese will range from about .1% to about 15% by weight.

Two highly satisfactory alloys which are now being used for the high expanding lamina by applicants' assignor in commercially fabricating this resistor are as follows:

(a) Chromium 15%, aluminum 4.25%, manganese .5%, balance iron;

(b) Chromium 17%, aluminum 7.5%, balance iron.

The low expanding lamina used with the above is Invar. The high and low expanding laminae are welded otherwise bonded together.

By referring to Fig. 1, it will be seen that the curve for the thermal expansion coefficients per degree F. of Invar (36% nickel, 64% iron) crosses the curve for the thermal expansion coefficients of the 15% chromium, 4.25% aluminum, balance iron alloy between 500° F. and 600° F. Thus, above about 500° F. the thermal expansion coefficients per degree F. of Invar are greater than the thermal expansion coefficients per degree F. of the chromium, aluminum, iron alloy. Thus, when an electrical resistor is made with the chromium, iron, aluminum alloy, shown in Fig. 1, as the high expanding lamina and with Invar as the low expanding lamina, when the resistor reaches temperatures of about 500° F. and above, the Invar actually has a higher expansion rate than the chromium, aluminum, iron alloy and in effect becomes at these temperatures the high expansion lamina.

This new and unexpected result is a very valuable asset in a circuit breaker, and especially on heavy or high amperage short circuits. Circuit breakers are invariably mounted in a housing designed as small as possible to effect the greatest possible economy in space. Thus, the electrical resistor is not always permitted free and unrestricted movement at all temperatures. The housing is usually designed so that the bi- or trimetal resistor can move freely within its normal temperatures of operation.

Frequently a stop is provided to arrest movement of the thermostatic metal above a certain temperature. By studying the deflection curve shown in Fig. 2, it will be seen that with the herein described laminated thermostatic metal the deflection curve has a negative slope beginning at about 500° F. This means that the thermostatic metal strip at temperatures above about 500° F., moves in an opposite direction from its direction of movement at temperatures up to about 500° F. Thus, in a circuit breaker the resistor would reverse its movement before coming against a stop or a wall of the housing and thus not take a permanent set. In other words, the instant resistor protects itself against injury.

By again referring to Fig. 2, it will be seen that the deflection curve of a standard thermostatic metal, such as a bimetal having a low expanding side of Invar and a high expanding side of 22% nickel, 3% chromium, and 75% iron, continues to rise from about room temperature and is still rising above 1200° F. As a matter of fact, this deflection curve does continue to rise for several hundred degrees above 1200° F. although not nearly as abruptly as below 1200° F. This means that in a temperature rise of say 100° F. to 1700° F. a standard laminated thermostatic metal, such

as above referred to by way of example, will continue to move in the same direction. A resistor of such a standard thermostatic metal would take a permanent set upon coming against a positive stop because the stresses in the metal would increase as the temperature rose even though the stop restricted movement. There is no tendency for the standard thermostatic metal to reverse its movement as in the case of the resistor with the high expanding lamina of chromium, aluminum and iron.

Another important factor and valuable asset shown by Figs. 1 and 2 is that the internal stresses of applicants' resistor above about 500° F. are materially less than in resistors made of standard types of laminated thermostatic metal. This is evident when one bears in mind the fact that stress is equal to one-half E (the modulus of elasticity of the thermostatic metal) $\times$ α (the difference in the thermal expansion coefficients of the laminae) $\times$ T (temperature change). D (deflection) equals K (a constant) $\times$ l^2 (the length squared) $\times$ T (the temperature change) divided by h (thickness). Thus the total deflection is the index of the thermal stress of the bimetal.

By reference to Fig. 2 it will be seen that the total deflection of a standard thermostatic metal is much greater than the instant resistor thermostatic metal and thus the internal stresses of the instant resistor thermostatic metal are much lower. This characteristic gives the resistor greater stability and a much more permanent calibration than is possible with resistors of standard thermostatic metal. This feature is particularly important when one bears in mind that in the Underwriters' Laboratory test to which all such circuit breakers are subjected, the circuit breaker is subjected to 5000 amperes for one-third of a cycle. In this test the temperature of the thermostatic metal rises sometimes as high as 1700° F. When the applicants' electrical resistor is subjected to this severe test the cabibration of the same is practically unaffected but the same is not at all true of a resistor of standard thermostatic metal due to the relatively greater internal stress of this material at such a high temperature.

It is the combination of the above described properties that give the instant resistor a usefulness not obtained by any other combination of alloys.

This application is a continuation-in-part of our application Serial No. 126,261, filed February 17, 1937, now abandoned.

We claim:

1. An electrical resistor of laminated thermostatic metal comprising high and low expanding laminae, the high expanding lamina being an alloy containing about 15% chromium, about 4.25% aluminum, about .5% manganese, and the balance iron, the low expanding lamina being a nickel-iron alloy comprising essentially nickel in an amount falling within a range of from 35% to 42% by weight and the balance iron.

2. An electrical resistor of laminated thermostatic metal comprising high and low expanding laminae, the high expanding lamina being an alloy containing about 17% chromium, about 7.5% aluminum, manganese in an amount falling within a range of from about .1% to about 15%, and the balance iron, the low expanding lamina being a nickel-iron alloy comprising essentially nickel in an amount falling within a range of from 35% to 42% by weight and the balance iron.

3. An electrical resistor of laminated thermostatic metal comprising high and low expanding laminae, the high expanding lamina comprising essentially an iron-chromium-aluminum alloy containing chromium in an amount falling within a range from about 10% to about 40% by weight, aluminum in an amount falling within a range from about 3% to about 10% by weight, and the balance principally iron, said low expanding lamina being a nickel-iron alloy the major portion of which is iron, the low expanding lamina being a nickel-iron alloy comprising essentially nickel in an amount falling within a range of from 35% to 42% by weight and the balance iron.

4. An electrical resistor of laminated thermostatic metal comprising high and low expanding laminae, the high expanding lamina being an alloy containing about 15% chromium, about 4.25% aluminum, about .5% manganese, and the balance iron, the low expanding lamina being a nickel-iron alloy comprising essentially nickel in an amount falling within a range of from 35% to 42% by weight and the balance iron.

5. An electrical resistor of laminated thermostatic metal comprising high and low expanding laminae, the high expanding lamina being an alloy containing about 17% chromium, about 7.5% aluminum, and the balance iron, said low expanding lamina being a nickel-iron alloy the major portion of which is iron.

6. An electrical resistor of laminated thermostatic metal comprising high and low expanding laminae, the high expanding lamina being an alloy containing chromium in an amount falling within a range from about 10% to about 40% by weight, aluminum in an amount falling within a range from about 3% to about 10% by weight, manganese in an amount falling within a range from about .1% to 15% by weight, and the balance iron, the low expanding lamina being a nickel-iron alloy comprising essentially nickel in an amount falling within a range of from 35% to 42% by weight and the balance iron.

7. An electrical resistor of laminated thermostatic metal having a low expansion lamina composed of nickel-alloy and a high expansion lamina composed essentially of a chromium-aluminum-iron alloy, the said chromium-aluminum-iron alloy having a lower coefficient of expansion per degree of temperature change above about 500° F. than the nickel-iron lamina, the low expanding lamina being a nickel-iron alloy comprising essentially nickel in an amount falling within a range of from 35% to 42% by weight and the balance iron.

8. An electrical resistor of laminated thermostatic metal having a low expansion lamina composed of a nickel-iron alloy containing from about 35% to about 42% by weight of nickel, and the remainder iron, and a high expansion lamina composed essentially of chromium in an amount falling within a range from about 10% to about 40% by weight, of aluminum in an amount falling within a range from about 3% to about 10% by weight, and the remainder iron, the said chromium-aluminum-iron alloy having a lower coefficient of expansion per degree of temperature change above about 500° F. than the nickel-iron lamina.

9. A laminated thermostatic metal element comprising a low expanding lamina of an alloy

of nickel and iron, the nickel ranging from about 35% to about 42% by weight and the balance iron, and a high expanding lamina affixed to the low expanding lamina of an alloy of chromium, aluminum and iron, chromium being present in said alloy in an amount falling within a range of from about 10% to about 40% by weight, aluminum being present in said alloy in an amount falling within a range of from about 3% to about 10% by weight, and the remainder principally iron, said laminated thermostatic metal having the characteristic of reversing its direction of deflection at a temperature of about 500° F.

10. A laminated thermostatic metal element comprising a low expanding lamina of an alloy of nickel and iron, the nickel ranging from about 35% to about 42% by weight and the balance iron, and a high expanding lamina affixed to the low expanding lamina of an alloy of chromium, aluminum, manganese and iron, chromium being present in said alloy in an amount falling within a range of from about 10% to about 40% by weight, aluminum being present in said alloy in an amount falling within a range of from about 3% to about 10% by weight, manganese being present in said alloy in an amount falling within a range of from about .1% to about 15% by weight, and the remainder iron, said laminated thermostatic metal having the characteristic of reversing its direction of deflection at a temperature of about 500° F.

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