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IRON ALLOY SUITABLE FOR ELECTRICAL RESISTANCES

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1 Claim. (Cl. 201—76)

This invention relates to iron alloys which are especially suitable for the manufacture of electrical resistances.

It is known that various alloys of iron, aluminum and carbon, with or without other metals such as chromium for example, are suitable for electrical resistance elements provided that the carbon content be very low, for instance below 0.05%. It is, however, a matter of expense and practical difficulty to maintain the carbon content sufficiently low to insure that the resistance elements will withstand high temperatures for a considerable period of time. It has been found that during annealing of the wire for further drawing, for instance, the carbon content may be raised from 0.05% to 0.1% or 0.15% by carburization, the carbon originating in the lubricant ordinarily used in wire drawing.

According to the present invention, it is found that the addition of titanium in an amount of at least three times the carbon percentage, considerably improves the life of iron-chromium-aluminum alloys when used for the purpose of electrical resistance wire exposed to high temperatures, notwithstanding that the carbon content after drawing and annealing may lie between the limits of about 0.1% and 1%. The titanium may be wholly or partially replaced if desired by one or both of the elements vanadium or zirconium, the proportions of these elements being related to the carbon content.

The range of constituents contemplated is:

Chromium, 6% to 30% and preferably 6% to 20%
Aluminum, 3% to 12%
Carbon, 0.03% to 1% and preferably to 0.5%.

Suitable additions of one or more of the other elements mentioned may be made, which in the case of titanium and vanadium, should not be less than three times the percentage of carbon and in the case of zirconium not less than six times the percentage of carbon. The effects of these elements are approximately additive and when more than one is used, the preferred minimum amounts will be determined according to the following formula:

$$\frac{\%Ti}{3}+\frac{\%V}{3}+\frac{\%Zr}{6}=\%\text{ carbon}$$

It is preferred that the excess of titanium, vanadium or zirconium above the minima specified should not exceed 2%. Certain impurities may be present and we have found for instance that the presence of up to say 0.75% manganese and up to say 0.30% silicon does not have any detrimental effect. The total amount of the titanium, vanadium or zirconium or any of these metals taken singly need not exceed 5%.

In the following examples alloys of various percentage compositions manufactured in accordance with my invention are given, and for the sake of comparison alloys having a closely similar percentage composition but without the addition of titanium and also the results of actual tests carried out on 25 S. W. G. wire in the bright drawn condition without subsequent heat treatment. These results serve to illustrate the vastly improved life in service obtained by means of the titanium additions. The resistivity is given in microhms per cubic centimetre, and the coefficient of increase of resistance with temperature is given over a range of from 20° C. to 1,000° C. The life test is in hours when the wire under a standard load of 35 lbs. per square inch was subjected to intermittent heating at a temperature of between 1,060° C. and 1,070° C., the heat being alternately two minutes on and two minutes off. In all the compositions the remaining constituent to make the full 100% consists substantially of iron:

Example 1

	Alloy according to present invention, cast S. G. 2007	Closely similar alloy without titanium, cast S. G. 835
Chromium percent	8.44	8.00
Aluminum do	6.42	6.30
Carbon do	0.085	0.13
Manganese do	0.41	0.32
Silicon do	0.22	0.18
Titanium do	0.50	Nil
Resistivity	121	119
Temperature co-efficient	1.85×10^{-4}	2.6×10^{-4}
Life test	400	24

Example 2

	Alloy according to the present invention, cast S. G. 1442	Closely similar alloy without titanium— Cast S. G. 1441	Cast S. G. 1537
Chromium percent	8.04	8.36	7.92
Aluminum do	5.14	4.78	5.50
Carbon do	0.10	0.10	0.09
Manganese do	0.58	0.48	0.41
Silicon do	0.28	0.26	0.14
Titanium do	0.69	Nil	Nil
Resistivity	112	108	111
Temperature coefficient	2.6×10^{-4}	*	*
Life test	390	18	63

*Too badly scaled during test to provide a reliable value.

Example 3

	Alloy according to the present invention, cast S. G. 1349	Closely similar alloy without titanium—	
		Cast No. 59*	Cast No. 61*
Chromium....percent..	12.84	13.91	11.31
Aluminum.....do....	5.30	6.48	5.98
Carbon.....do....	0.085	0.06	0.03
Manganese.....do....	0.62	†	†
Silicon.....do....	0.30	†	†
Titanium.....do....	0.96	Nil	Nil
Resistivity.....	126	139	132
Temperature coefficient	1.4×10^{-4}	†	†
Life test.....	853	158	189

*Size of wire in these two instances=0.025".
†Not determined.

It will be observed that the life of the alloy according to the present invention is very much greater than the life of alloys having closely similar compositions but not including titanium.

I declare that what I claim is:

Electrical resistance element composed of an alloy wire containing chromium 6% to 30%; aluminum 3% to 12%; carbon in a percentage sufficient detrimentally to affect the life of the element and between about 0.1% and 1%; and the balance principally iron and an effective amount of at least one element selected from the group titanium, vanadium, and zirconium, such amount being less than 5% but sufficient to overcome the detrimental effects of the carbon and being at least enough to satisfy the equation:

$$\frac{\%\ \mathrm{Ti}}{3}+\frac{\%\ \mathrm{V}}{3}+\frac{\%\ \mathrm{Zr}}{6}=\%\ \text{carbon}$$

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