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ELECTRICAL RESISTANCE ALLOYS

Hugh S. Cooper, Cleveland, Ohio

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10 Claims. (Cl. 75-124)

This invention relates to electrical resistance alloys and to heating elements comprised thereof.

One object of the invention is to provide a relatively low cost electrical resistance alloy.

Another object is to provide a relatively low cost electrical resistance heating element.

A further object is to provide an improved electrical resistance heating element.

Other objects will be apparent as the invention is more fully hereinafter disclosed.

This application is a continuation-in-part application of application Serial No. 505,038 filed October 5, 1943, entitled Rust and oxidation resistant alloys.

In accordance with the above objects I have discovered that an iron alloy containing aluminum, chromium and columbium, each within relatively narrow and critical percentage ranges, is characterized by being highly ductile and cold workable to relatively small diameter wire or thin sectioned strip form, high resistance to surface oxidation and corrosion at atmospheric temperatures, highly resistant to oxidation at elevated temperatures up to about 1000° to 1100° C. and, in addition, is characterized by an electrical resistance approximating 600 ohms per circular mil foot at 25° C. and by a temperature coefficient of electrical resistivity per degree C. approximating .0005 to .0006 between 50° and 650° C.

These physical and electrical characteristics of the alloy composition of the present invention adapt the material to wide utility as an electrical resistance heating element in various types of electrical devices.

In the alloy composition of the present invention, I have discovered that the electrical properties and the resistance to oxidation at elevated temperatures are imparted to the alloy by an aluminum content within the range 5.25 to 7.5% and a chromium content within the range 2 to 4% and that resistance to oxidation and corrosion at atmospheric temperatures is imparted by columbium within the range .25 to 2%. In my alloy, carbon is preferably substantially excluded and in no event must exceed .20% and when carbon is present in amounts up to .20% the columbium content is increased from the minimum of .25% to an amount at least .25% in excess of 8 times the carbon, to prevent the formation of chromium carbide compounds detrimentally affecting the chromium content of the alloy thereby changing or altering the desired electrical properties and high temperature oxidation resistance properties of the alloy. Manganese and silicon in amounts up to .50% are permissible con-

stituents of the alloy but are not essential thereto except insofar as they may be utilized as de-oxidizing agents in the iron base of the alloy in the manufacture of the alloy, in accordance with best prior art practice.

As specific examples of the present invention the following examples are given:

	I	II	III
Al.	6.67	7.34	5.20
Cr.	3.31	4.03	2.25
Life at 1050° C. (hours)	524	281	155

In the above alloys, the columbium content approximates .65%; manganese .50%; silicon .20%; and the carbon .04% with the balance iron. Under similar test conditions the nickel-chromium alloy known in the art under the trade-name "Nichrome" evidences a life of about 150 hours.

Of the various alloy compositions possible under the narrow range of constituents above given the alloy containing about 6.5% Al and 3.25% Cr or Al and Cr in the ratio of 2:1 with about .05 carbon and .65% columbium, appears to provide the longest life under the accelerated life test conditions customarily applied to such electrical resistance alloys. This alloy in a plurality of tests has consistently shown a total life at 980° C. of over 1200 hours to a 5% change in resistance without burn-out. The electrical resistance of this specific alloy approximates 575 ohms per circular mil foot and the material consistently shows a maximum temperature coefficient per degree C. between 50° C. and 650° C. of .000543.

The alloy of this specific composition is highly ductile and may be cold drawn into small diameter wire or cold rolled into thin sectioned strip material and may be readily coiled about a mandrel into relatively small diameter heater element coils.

In the alloy composition of the present invention any increase in the aluminum or chromium content above the maximum limits of 7.5% and 4%, respectively, or any decrease of the same constituents below the minimum limits of 5.25% and 2.0%, respectively, markedly effects the oxidation resistance of the alloy at high temperatures. As an indication of this, in an alloy containing about 8.66% aluminum and about 2.5% chromium, an operating life at 1050° C. of only 59 hours was obtained on test; in an alloy about 6.25% aluminum and about 1.25% chromium a life at 1050° C. of only 89 hours was obtained on test. In the first alloy the Al content is above

the maximum percentage specified and the chromium is well within the range specified, yet the test life at 1050° C. is about one-third that of nickel-chromium (ni-chrome). In the second alloy, the aluminum content is well within the range specified and the chromium below the minimum percentage specified, yet the test life is only about one-half that of nickel-chromium (ni-chrome).

Further experiments have shown that an increase in the chromium content of the first alloy noted immediately above, to about 5% instead of improving the test life, actually lowered the test life from 59 hours to 39 hours. To demonstrate the converse of the above, an alloy containing 4.65% Al and 6.89% Cr showed a test life of only 22 hours.

Various other tests have indicated that aluminum over 7.5% and Cr under 2.0% are each detrimental to the operating life at elevated temperature and that as long as the Al and Cr are within the ranges 5.25-7.5% and 2.0-4.0%, respectively, an operating life at elevated temperatures at least as long as that obtainable from nickel-chromium (ni-chrome) alloys may be expected, and that when the aluminum content is approximately 6.0-6.5% and the chromium content is approximately one-half of the aluminum content an operating life from 2 to 3 times as that of nickel-chromium (ni-chrome) alloys may be obtained. Accordingly, within the broad ranges of Al and Cr specified the ratio of Al to Cr of 2 to 1 appears critical to a long operating life at high temperatures.

Having hereinabove disclosed the present invention broadly and specifically and having given several specific examples of the same, it is believed apparent that the same may be varied widely without essential departure therefrom and all such modifications and departures are contemplated as may fall within the scope of the following claims:

What I claim is:

1. An electrical resistance alloy, said alloy consisting of from 5.25%-7.50% Al, 2-4% Cr, .25-2% Cb, balance Fe.
2. An electrical resistance alloy, said alloy consisting of from 5.25-7.50% Al, 2-4% Cr, .25-2.0% Cb, carbon not over .20% with the Cb content at least .25% in excess of 8 times the carbon, balance Fe.
3. An electrical resistance alloy, said alloy consisting of 5.25-7.50% Al, 2-4% Cr, not over .50% each of Mn and Si, carbon not over .20%, Cb .25% in excess of 8 times the carbon, balance Fe.
4. An electrical resistance alloy, said alloy consisting of Al 5.25-7.50%, Cr approximately one-half the Al, carbon not over .20%, Cb .25% in excess of 8 times the carbon, balance Fe.
5. An electrical resistance alloy, said alloy consisting of Al 5.25-7.50%, Cr approximately one-half the Al, carbon not over .20%, Cb .25% in excess of 8 times the carbon, balance Fe, Mn and Si each not over .50%.
6. An electrical resistance alloy, said alloy consisting of 6.5% Al, 3.25% Cr, .05% C, .65% Cb, balance Fe.
7. An electrical resistance alloy, said alloy consisting of 6.5% Al, 3.25% Cr, .05% C, .65% Cb, Mn and Si each not over .50%, balance Fe.
8. An electrical resistance element comprised of an alloy consisting of from 5.25-7.5% Al, 2-4% Cr, not over .20% C, Cb .25% in excess of 8 times the carbon, balance Fe.
9. An electrical resistance element comprised of an alloy consisting of from 5.25-7.5% Al, 2-4% Cr, not over .20% C, Cb .25% in excess of 8 times the carbon, Mn and Si each not over .50%, balance Fe.
10. An electrical resistance element comprised of an alloy consisting of 6.5% Al, 3.25% Cr, .05% C, .65% Cb, balance Fe.

HUGH S. COOPER.