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ELECTRICAL RESISTANCE ALLOY

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This invention relates to electrical resistance alloys and more particularly to the electro-magnetic type of high temperature electrical resistance alloys known in the art as iron-chromium-nickel alloys which contain from 10 to 30% Cr, from 5 to 50% Fe with the balance of the alloy consisting of Ni.

One object of the present invention is to increase the electrical resistance of said alloys and to lower the temperature coefficient of resistivity thereof, thereby to obtain a more efficient resistor element.

Another object is to provide an improved high temperature electrical resistor alloy and resistor element made therefrom.

Still another object is to improve the electrical resistance and the temperature coefficient of resistivity characteristics of iron-chromium-nickel electrical resistance alloys.

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

In accordance with these objects we have discovered that aluminum and copper additions in amounts ranging from 1.5 to 8% Al and 1.5 to 4% Cu are effective in obtaining an increase in the electrical resistance and a decrease in the temperature coefficient of resistivity in iron-chromium-nickel alloys of the high temperature resistor type.

As one specific embodiment of the present invention, the same will be described in connection with an alloy containing Fe 25%, Cr 15%, balance Ni. This alloy is old and well known in the art, per se, and is widely used as a high temperature resistor element in rheostats, electric heating elements, etc., where operating temperatures as high as 1850° F. may be desired. This alloy is known to have an electrical resistance of about 675 ohms per C. M. F. and a temperature coefficient of about .00022 per ohm per degree centigrade.

We have found that aluminum and copper additions to this alloy in the ranges 1.5 to 8.0% and 1.5 to 4.0% respectively with the Al and Cu being in the ratio range of 1 to 1 up to 2 to 1, increases the electrical resistance of the alloy from 675 ohms per C. M. F. up to a value closely approximating 1000 ohms per C. M. F. and lowers the temperature coefficient of resistivity from the value .00022 to about .000094, without otherwise being deleterious to the physical and chemical properties of the alloy, such as, its hot and cold workability, its high temperature oxidation resistance, or its normal resistance to corrosive attack.

As specific examples of the improved alloy of the present invention the effect of increasing Al and Cu on the electrical resistance and temperature coefficient of resistivity of an alloy containing 25% Fe, 15% Cr, balance Ni, is indicated in the following table:

Alloy No.	Al	Cu	Fe	Cr	Ni	E.R./C.M.F.	T. C.
1			25	15	60	675	.00022
2	1.5	1.5	25	15	57	752	.000141
3	4.0	3.0	25	15	53	807	.000133
4	4.5	3.0	25	15	52.5	826	.000128
5	5.0	3.0	25	15	52.0	837	.000108
6	8.0	4.0	25	15	48.0	950	.00008

In the above table "E. R./C. M. F." is an abbreviation of "electrical resistance per circular mill foot at 20° C." and "T. C." is an abbreviation of "temperature coefficient of resistivity" which is usually determined over a range of temperatures below 300° C.

As indicated in the table the addition of Al and Cu in amounts ranging from 1.5 to 8% Al and 1.5 to 4% Cu, in substitution for an equivalent amount of Ni, markedly increases the electrical resistance of the alloy and at the same time markedly lowers the temperature coefficient of electrical resistivity. With increasing Al and Cu content, the electrical resistance increases and the temperature coefficient of resistivity decreases. Cu additions in excess of about 4% to the alloy, however, detrimentally effects the hot working properties of the alloy and Al additions in excess of 8% detrimentally effect both the hot and cold workability of the alloy. However, with copper 4% and Al 8%, the hot and cold workability of the alloy is such that it may be mechanically reduced to the smallest diameter wires normally employed with alloys of this type, for example, to .001 inch, and, with appropriate care, to sizes as small as .0007 inch, if desired. In the above table, the size at which the above values were determined was .0055 inch diameter.

In the above specific alloy, the chromium content may vary within the range 10–30% with corresponding increase or decrease in the nickel content without departure from the present invention, but with corresponding variation in the electrical resistance and temperature coefficient of resistivity values as one skilled in the art will recognize. Such alloys, however, will show the same trend of increasing and decreasing "E. R./C. M. F." and "T. C." values, respectively, that are indicated in the above table.

Iron variations within the range 5 to 50% in

the alloy of the present invention effect primarily the operating temperature of the alloy and secondarily effect the total Al and Cu that may be added without detrimentally effecting the hot and cold workability of the alloy.

As an illustration, the normal operating temperature of the 25% Fe alloy of the above specific embodiment is about 1850° F. With iron as high as 50% the operating temperature drops to about 1600° F. With iron as low as 5% the operating temperature increases to about 2000° F.

As the iron increases to 50% the total Al and Cu that may be added to the alloy without detrimentally effecting the hot and cold workability increases to about 14%, with Al about 10% and Cu not over about 4%. As the iron decreases to 5% the total Al and Cu that may be added to the alloy without detrimentally effecting the hot and cold workability of the alloy decreases to about 9% with Cu about 3% and Al about 6%.

As another specific example of the present invention an alloy containing Cr 13%, Fe 6.5%, Al 5%, Cu 3%, balance Ni, has been found to have an E. R./C. M. F. of about 795 ohms and a T. C. of about .000034 ohm, with an operating temperature of about 2000° F.

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

What we claim is:

1. An electrical resistance alloy having a temperature coefficient of resistivity below .00022, said alloy consisting of Cr 10–30%, Fe 5–50%, Al 1.5 to 8%, Cu 1.5 to 4%, with the Al to Cu within the ratio range of 1 to 1 and 2 to 1, balance Ni.

2. An electrical resistance alloy having a temperature coefficient of resistivity below .00022, said alloy consisting of Cr 10 to 30%, Fe 25%, Al 1.5 to 8.0%, Cu 1.5 to 4.0%, with the Al to Cu within the ratio range of 1 to 1 and 2 to 1, balance Ni.

3. An electrical resistance alloy having a temperature coefficient of resistivity below .00022, said alloy consisting of Cr 15%, Fe 25%, Al 1.5 to 8%, Cu 1.5 to 4%, balance Ni.

4. An electrical resistance alloy having a temperature coefficient of resistivity of about .000141, said alloy consisting of Cr 15%, Fe 25%, Al 1.5%, Cu 1.5%, balance Ni.

5. An electrical resistance alloy having a temperature coefficient of resistivity of about .000128, said alloy consisting of Cr 15%, Fe 25%, Al 4.5%, Cu 3%, balance Ni.

6. An electrical resistance alloy having a temperature coefficient of resistivity of about .00008, said alloy consisting of Cr 15%, Fe 25%, Al 8%, Cu 4%, balance Ni.

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