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NICKEL ALLOY AND ELECTRICAL RESISTOR ELEMENT MADE THEREOF

Victor O. Allen, Madison, N. J.

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This invention relates to electrical resistance alloys, particularly those utilizable as a resistor element in electrical devices, apparatus and circuits wherein, in addition to desirable physical and electrical properties, surface stability and high resistance to surface oxidation and corrosion particularly upon exposure to marine atmosphere is of primary importance.

The object of the invention is to provide an electrical resistance alloy meeting these exacting requirements.

Another object is to provide an electrical resistance alloy characterized by being capable of being mechanically deformed into small diameter wire of relatively high tensile strength, by high surface stability and resistance to corrosion especially in marine atmospheres, and by electrical resistance properties adapting the same to wide utility in the art as a resistor element in electrical devices of all types and especially in devices and contrivances known generally in the art as radio, radar, telephone, telegraph and the like.

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

In accordance with these objects I have discovered that the addition of silver and aluminum, each in amounts ranging from small fractional percentages up to 5%, but in total amount not exceeding about 8%, to chromium-nickel alloys containing from 10 to 30% chromium, functions to increase the electrical resistance of the base Cr-Ni alloy and to lower the temperature coefficient of electrical resistivity of the alloy while at the same time increasing the tensile strength of the alloy and imparting to the alloy high surface stability and resistance to corrosion especially resistance to corrosion in marine (salt) atmospheres.

As one specific embodiment of the present invention, but not as a limitation thereof, the adaptation of the same to a well known nickel-chromium alloy containing 80% nickel and 20% chromium will be described.

The usual temperature coefficient of electrical resistivity (T. C.) of a nickel-chromium alloy containing 80% Ni and 20% Cr within the temperature range 20°–100° C. is .00014 ohms per ohm per degree centigrade. The electrical resistance of such an alloy at 20° C. usually approximates 650 ohms per circular mil foot (C. M. F.).

The T. C. of this alloy is too high for use as a resistor element in high accuracy electrical devices, apparatus and circuits. In such devices, apparatus and circuits, a resistor material having a T. C. below .0001 and as close to .00001 as possible is desired.

I have found that by the addition of silver and aluminum to the nickel-chromium alloy, in substitution for the nickel content thereof, in total amount not exceeding 8% but not over about 5%

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of either metal, the T. C. of the alloy is progressively lowered with increase in the total amount of the two metals present until with about 6 to 8% total Ag and Al with each in approximately equal amounts a T. C. as low as .00001 to .00002 may be obtained in the alloy.

In addition to progressively lowering the T. C. I have found that the electrical resistance of the alloy also is increased from about 650 ohms (C. M. F.) to as high as 950 ohms (C. M. F.) depending upon the total amount of Ag and Al present in the alloy and the relative proportions thereof.

Whereas, the major objective of the present invention is to provide a surface stabilized alloy having electrical and physical properties adapting the same for use as an electrical resistor in high accuracy electrical devices, apparatus and circuits, the invention will be described with respect to a species alloy composition particularly suited for this major objective.

I have found that to impart high surface stability towards the corrosive action of sea air, the silver content of the alloy should at least approximate 3%. Silver in amounts under 3% impart some surface stability but not enough to fully insulate the alloy against corrosion by saline atmospheres. On the other hand, silver in excess of 5% appears to be unnecessary either electrically or for corrosion resistance.

Aluminum in amounts over 5% is highly undesirable for the reason that it detrimentally affects both the hot and cold workability of the alloy. It is preferable to maintain the aluminum within the range 3 to 4%. Within these ranges of 3 to 5% Ag and 3 to 5% Al providing high corrosion resistance and surface stability with favorable electrical properties the following composition examples are given:

(1) *An alloy containing 5% Al, 3% Ag, 20% Cr, balance Ni*

This alloy, in wire form, has an electrical resistance of about 950 ohms per circular mil foot at 20° C. and a temperature coefficient of resistivity approximating .00001 ohms per ohm per degree centigrade within the range 100° to 300° C.

(2) *An alloy containing 4% Al, 3% Ag, 20% Cr, balance Ni*

This alloy, in wire form, has an electrical resistance approximating 850 ohms per circular mil foot at 20° C. and a temperature coefficient of resistivity approximating .00002 ohms per ohm per degree centigrade within the range 100°–300° C.

(3) *An alloy containing 3% Al, 3% Ag, 20% Cr, balance Ni*

This alloy, in wire form, has an electrical re-

sistance approximating 775 ohms per circular mil foot at 20° C. and has a temperature coefficient of resistivity of about .00004 ohms per ohm per degree centigrade within the range 100°–300° C.

The above alloys being characterized by a fully austenitic structure and therefore non-magnetic are each also characterized by having an electrical resistance and a temperature coefficient of resistivity particularly adapting the same for wide utility in the art of electrical devices, apparatus and circuits as electrical resistors, in addition to which the high silver content of the alloys imparts high surface stability and resistance to corrosion by saline atmospheres, due it is believed to the formation of a tightly adherent silver chloride film over the surface of the alloy inhibiting further corrosion. In addition the chromium content of the alloy normally protects the alloy against surface oxidation.

Each of these alloys may be hot and cold worked and may be drawn into relatively small diameter wires. The tensile strength of the alloys is considerably higher than that of other alloys heretofore employed, permitting winding of the same into coils under high tension. As an illustration, the alloys of the specific embodiments generally have a tensile strength approximating 150,000 p. s. i.

In general, in alloys wherein the silver content is below 3%, aluminum within the range 4 to 5% is preferred in order to obtain the higher electrical resistances and the lower temperature coefficients of resistivity.

In the manufacture of the alloy compositions of the present invention the silver and aluminum is added to the molten Ni.Cr alloy after the molten Ni.Cr alloy has been thoroughly deoxidized and degasified by the usual deoxidizing and degasifying agents to prevent excessive losses of the aluminum particularly. Therefore, insofar as the term "balance nickel" is concerned as it may hereinafter appear in the claims, this term is to be construed as including small fractional percentages of such deoxidizing and degasifying agents which generally include one or more of the elements of the group consisting of Mn, Si, Ti, Zr and B.

Whereas, in the above specific examples, an alloy containing 20% Cr is disclosed, it is believed apparent that the chromium may be varied within the range 10 to 30% with resultant increase and decrease in the nickel content of the alloy, without essential departure from the present invention, obtaining thereby a variation in the electrical resistance and the specific temperature coefficient of resistivity of the alloy, the effect of the Al and Ag additions on any given nickel-chromium alloy being substantially the same and equivalent to that indicated for the 80 Ni-20 Cr base alloy of the specific examples, but of a different order.

From the above disclosure of the present invention it is believed apparent that the same may be widely varied without essential departure therefrom and all such are contemplated as may fall within the scope of the following claims.

What I claim is:

1. An electrical resistor element for high accuracy electrical devices, apparatus and electrical circuits, said element being comprised of an alloy having a temperature coefficient of resistivity below .0001 ohms per ohm per degree centigrade at temperatures within the range 100–300° C. and a specific resistance at 20° C. substantially above 650 ohms, said alloy consisting of 10–30% chromium, silver and aluminum, each in amounts within the range 3% to 5% but in total amount within the range 6% to 8%, balance nickel, said alloy being further characterized by having a surface which is resistant to corrosion in saline atmospheres.

2. The resistor element of claim 1, said element being comprised of an alloy consisting of 20% Cr, 5% Al, 3% Ag, balance Ni, said alloy having a temperature coefficient of resistivity approximating .00001 ohms per ohm per degree centigrade within the range 100–300° C. and a specific resistance at 20° C. approximating 950 ohms per circular mil foot.

3. The resistor element of claim 1, said element being comprised of an alloy consisting of 20% Cr, 4% Al, 3% Ag, balance Ni, said alloy having a temperature coefficient of resistivity approximating .00002 ohms per ohm per degree centigrade within the range 100°–300° C. and a specific resistance at 20° C. approximating 850 ohms per circular mil foot.

4. The resistor element of claim 1, said element being comprised of an alloy consisting of 20% Cr, 3% Al, 3% Ag, balance Ni, said alloy having a temperature coefficient of resistivity of approximating .00004 ohms per ohm per degree centigrade within the range 100–300° C. and a specific resistance at 20° C. approximating 775 ohms.

5. An alloy characterized by electrical and physical properties adapting the same for use as a resistor element in high accuracy electrical circuits, said alloy consisting of chromium 10 to 30%, Al and Ag each in amounts within the range 3 to 5% but in total amount within the range 6 to 8%, balance Ni, said alloy having a temperature coefficient of resistivity within the range 100–300° C. below .0001 ohms per ohm per degree centigrade and an electrical resistance substantially above 650 ohms per circular mil foot at 20° C. and being further characterized by being resistant to corrosive attack in saline atmospheres.

6. The alloy of claim 5, wherein within the range 6 to 8% total amount the Al and Ag are approximately of equal percentages and wherein the temperature coefficient of resistivity of the said alloy is within the range .00001 to .00002.

VICTOR O. ALLEN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,925,978	Cooper	Sept. 5, 1933
2,293,878	Allen et al.	Aug. 25, 1942

FOREIGN PATENTS

Number	Country	Date
18,212	Great Britain, 1913	July 9, 1914
255,919	Germany	Jan. 23, 1913
256,361	Germany	Feb. 6, 1913

OTHER REFERENCES

Smith, "General Chemistry for Colleges," Second Edition, 1916, published by The Century Co., New York, page 500.

Hodgman et al., "Handbook of Chemistry and Physics," 26th Edition, 1942, pub. by Chemical Publishing Co., Cleveland, Ohio, pages 1852, 1854, 1858, 1860, and 1862.