Patented Aug. 25, 1942 2,293,878

UNITED STATES PATENT OFFICE

2,293,878

ELECTRICAL RESISTANCE ALLOY

Victor O. Allen, Madison, and Joseph F. Polak, Newark, N. J., assignors to Wilbur B. Driver Company, Newark, N. J., a corporation of New Jersey

No Drawing. Application March 30, 1942, Serial No. 436,912

5 Claims. (Cl. 75—171)

This invention relates to electrical resistance alloys and has for its object the provision of a high resistance alloy having a relatively low temperature coefficient of resistivity, particularly in the range of temperatures below about 300° C.

Another object is to provide an electrical resistance alloy suitable for use as a resistor element in electrical devices, apparatus and circuits.

Still another object is to provide an electrical resistance alloy consisting predominately of nickel and containing chromium 10% to 30% in which the normal electrical resistance is materially increased and the temperature coefficient of resistivity is materially lowered without material loss of hot and cold workability.

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

In accordance with these objects, we have discovered that copper and aluminum, in combination, are particularly effective, in alloys of nickel and chromium, as agents for increasing the electrical resistance of the alloy and for lowering the temperature coefficient of resistivity and that, in general, copper in amounts up to 3% and Al in total amounts up to 5%, but Cu and Al combined in total amount not over about 6% may be employed for this purpose without seriously impairing the normal hot and cold workability of the base nickel-chromium alloy.

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% Ni and 20% Cr heretofore employed as an electric resistance alloy will be described.

The normal temperature coefficient of resistivity of a nickel-chromium alloy containing 80% Ni and 20% Cr within the temperature range 20°–100° C. is .00014 ohm per ohm per degree centigrade, and the electrical resistance at 20° C. approximates 650 ohms per circular mil foot (C. M. F.). The temperature coefficient of resistivity of this alloy is too high for use as a resistor element in high accuracy electrical devices, apparatus and circuits. It is desired by the practice of the present invention to lower the temperature coefficient of resistivity of this alloy to a value below .00014 ohm. We have discovered that copper and aluminum additions to this alloy in total amount not over about 6% with copper not over about 3% and Al not over about 5%, will effectively lower the temperature coefficient of resistivity of the nickel-chromium alloy from the normal value of .00014 ohm to a value as low as .00002, and will at the same time markedly increase the electrical resistance of the alloy at any temperature within the range 20° C.–300° C.

In general, the copper and aluminum additions to the alloy are made at the expense of the nickel content of the alloy and may be added in various percentages within the ranges above given and in different relative proportions to obtain a plurality of high resistance alloys of progressively lower temperature coefficients of resistivity and different electrical resistances.

A copper content much in excess of about 3% is undesirable for the reason that the hot workability of the alloy is detrimentally effected. An Al content of much over 5% is undesirable for the reason that both the hot and cold workability of the alloy is deterimentally effected. A total amount of over about 6% of the two constituents (Al and Cu) is undesirable for the reason that cold drawing properties of the alloy, especially at small diameters, appears detrimentally effected.

The following three (3) examples of the present invention are illustrative of the effect of variation of Al and Cu within the ranges given on the electrical resistance and the temperature coefficient of resistivity of the base Cr-Ni alloy employed:

(1) An alloy containing Al 4%, Cu 2%, Cr 20% and Ni 74%.

This alloy, in wire form, has an electrical resistance of about 900 ohms per circular mil foot at 20° C. and has a temperature coefficient of resistivity of .000007 ohm per ohm per degree centigrade.

(2) An alloy containing Al 4%, Cu .50%, Cr 20%, and Ni 75.50%.

This alloy, in wire form, has an electrical resistance of about 800 ohms per circular mil foot at 20° C. and has a temperature coefficient of resistivity of .00004 ohms per ohm per degree centigrade.

(3) An alloy containing Al 3%, Cu 3%, Cr 20% and Ni 74%.

This alloy, in wire form, has an electrical resistance of about 775 ohms per circular mil foot at 20° C. and has a temperature coefficient of resistivity of .00002 ohm per ohm per degree centigrade.

Alloy #3, above, as far as its temperature coefficient of resistivity is concerned is equal to the

usual type of Cu-Ni and Cu-Mn-Ni resistor alloys heretofore employed in electrical devices, apparatus and circuits, such as those known in the art as "Cupron" (Cu 55%; Ni 45%) and "Manganin" (Cu 84%; Mn 12%; Ni 4%) but has an electrical resistance of 775 as compared to an electrical resistance of about 290 for these old types of alloys.

Alloy #1, as far as its temperature coefficient of resistivity is concerned is far better than the well known Fe-Cr-Al alloy known in the art as "ohmaloy" containing 80% Fe, 15% Cr and 5% Al, and has a materially higher electrical resistance, with the added advantage that alloy #1 is austenitic in structure and is non-magnetic. It, therefore, is of greater utility for use as radio resistor elements than is the "Ohmaloy" alloy.

Alloy #2 is about half as good as alloy #3 insofar as its temperature coefficient of resistivity is concerned, but its materially higher electrical resistance over either "Cupron" or "Manganin" places it in a position to be preferred over these alloys as instrument and radio resistors, shunts and in various types of thermocouples.

In the manufacture of the above alloys, the Al and Cu is added to the molten Ni-Cr, preferably after the molten Ni-Cr has been thoroughly deoxidized and degasified by the usual degasifying agents and insofar as the term "balance Ni" 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, B.

Whereas in the above specific embodiments, an alloy containing 20% Cr is disclosed, it is believed apparent that the Cr may be varied within the range 10 to 30% with resultant increase and decrease in the Ni balance 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 Cu additions on any given Cr-Ni base alloy being substantially the same and equivalent to that indicated for the 80 Ni–20 Cr base alloy of the specific embodiments given, but of a different order.

From the above description of the present invention and the three specific embodiments thereof, 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 we claim is:

1. An electrical resistance alloy consisting of chromium 10 to 30%, Al from small fractional percentages up to about 5%, Cu from small fractional percentages up to about 3%, with the total Al and Cu not over about 6%, balance nickel.

2. An electrical resistance alloy consisting of chromium about 20%, Al from small fractional percentages up to about 5%, Cu from small fractional percentages up to about 3%, with the total Al and Cu not over about 6%, balance nickel.

3. An electrical resistance alloy consisting of chromium 20%, Al 4%, Cu 2%, balance Ni.

4. An electrical resistance alloy consisting of Cr 20%, Al 4%, Cu .50%, balance Ni.

5. An electrical resistance alloy consisting of Cr 20%, Al 3%, Cu 3%, balance Ni.

VICTOR O. ALLEN.
JOSEPH F. POLAK.