United States Patent Office 2,858,208
Patented Oct. 28, 1958

2,858,208

NICKEL BASE ALLOY FOR USE AS AN ELECTRICAL RESISTANCE ELEMENT

Norman F. Spooner, Dearborn Township, Wayne County, Mich., assignor to The Hoskins Manufacturing Company, Detroit, Mich., a corporation of Michigan

No Drawing. Application December 16, 1955
Serial No. 553,440

4 Claims. (Cl. 75—171)

This invention relates to alloys and more particularly to alloys suitable for use as electrical resistance elements.

At the present time, the manufacture of alloys for use as electrical resistance elements has presented problems in that no single alloy has been developed which can be used successfully for long periods of time throughout a temperature range to about 2200° F. Some alloys, such as the extensively used alloys of the type containing about 80% nickel and 20% chromium, have a relatively long life at high temperatures, say from 2000° F. to 2200° F.; but they are subject to green rot corrosion in a temperature range of about 1500° F. to 1800° F. in some reducing atmospheres. On the other hand, other alloys of the type containing about 35% nickel, 18½% chromium and the balance iron resist green rot corrosion, but have a very short life at temperatures above 2000° F. Of these alloys, this latter group oxidize quite readily in an oxidizing atmosphere in this high temperature range and also have a low resistance to carburization. The carburization of electrical resistance alloys decreases the melting point of the alloy; and, of course, this is very detrimental when the resistance element is operating at a temperature relatively close to its melting point. In addition, carburization of such elements tends to increase the volume of the element, thus producing distortion and often causing one turn of the element to short out with the adjacent turn. In alloys of the 80% nickel-20% chromium type, carburization not only lowers the melting point, but also causes a decrease in electrical resistance, thus resulting in the element operating at a higher temperature with the same voltage. Since the rate of carburization tends to vary as a lineal ratio with respect to temperature, it can be readily understood that once carburization of the heating elements begins, burnouts could occur in a very short time.

The pick-up of sulfur by an electrical resistance element is likewise very detrimental, since sulfur has an even more potent effect on the lowering of the melting point of the alloy.

It is an object of this invention to produce an alloy which is admirably suited for use as an electrical resistance element and which has a relatively long life when used in the temperature range of from 2000° F. to 2200° F. and which, at the same time, is not subject to green rot corrosion when used in the temperature range of from about 1500° F. to 1800° F.

I have found that an alloy containing about 20% chromium and about 70% nickel can be modified by suitable alloy additions to produce a resistance heating element which possesses remarkable properties. The element of this invention is very resistant to green rot corrosion, it has a longer life at high temperatures than any similar electrical resistance alloy with which I am familiar and its resistance to carburization and sulfur pick-up is greater than other similar alloys with which I am familiar. The alloy of this invention has a composition somewhat similiar to the material sold by The Hoskins Manufacturing Company of Detroit, Michigan, and known as Alloy 798.

Alloy 798 is not an alloy especially adapted for use as an electrical resistance element. This alloy is used primarily for structural members in high temperature work. Alloy 798 has substantially the following composition: Nickel 69.5%, chromium 20.0%, iron 8.3%, manganese 0.5%, silicon 1.4% and carbon .10% maximum. Alloy 798 is not very susceptible to green rot corrosion. The iron content of this alloy is sufficiently high to normally resist green rot corrosion. However, at 2150° F., this alloy has a useful life, as defined by the ASTM standard life test for resistance alloys, of about 100 hours or less. On the average, the best 80% nickel-20% chromium alloys have a useful life at 2150° F. of slightly over 200 hours. The resistance to carburization of Alloy 798 is somewhat greater than 80% nickel-20% chromium alloys. For example, in carburization tests conducted with numerous alloys for two hours at 2000° F. in an atmosphere having a 1% carbon potential to steel, an 80% nickel-20% chromium alloy picked up .62% carbon while Alloy 798 picked up .42% carbon.

I have discovered that by modifying the composition of Alloy 798 slightly, namely, by the addition of small amounts of cobalt and columbium to the composition, the useful life and the total life of elements made with such alloys are greatly increased; and the resistance to carburization and sulfur pick-up is likewise substantially improved. For example, a resistance heating element made from an alloy containing 67.75% nickel, 20.0% chromium, 8.3% iron, 0.5% manganese, 2.0% silicon, less than .10% carbon, 1.0% cobalt and 0.25% columbium was tested at 2150° F. and found to have a useful life of 265 hours and a total life of 596 hours as compared with a useful life of about 100 hours for Alloy 798 and slightly over 200 hours for an 80% nickel-20% chromium alloy. This same alloy, when tested for susceptibility to carburization, was found to have picked up .09% carbon as compared with a pick-up of .42% for the Alloy 798 and .62% for the 80% nickel-20% chromium alloy referred to above. At the same time, it was found in testing the alloy of this invention, Alloy 798 and an 80% nickel-20% chromium alloy that the sulfur pick-up of the alloy of this invention was lower than the other two alloys. For example, in a two hour test at 1600° F. to 1800° F. in an atmosphere of 10% H_2S and the balance hydrogen, the sulfur pick-up of the alloy of this invention amounted to .38% and .77% for the 80% nickel-20% chromium alloy.

In carrying out the invention, best results are obtained if small additions of calcium, aluminum and cerium are added to the molten metal. The calcium may be added as calcium silicide and the cerium as misch-metal. The proportions of the various constituents may vary within the following ranges: Nickel 60% to 75%, chromium 18% to 22%, iron 7% to 10%, manganese 1.0% maximum, silicon 1.5% to 2.5%, carbon .15% maximum, cobalt 1.0% to 2.0% and columbium .25% to 1.0%.

Thus, it will be seen that by modifying the composition of Alloy 798 primarily by the addition of small amounts of cobalt and columbium, I have produced an alloy which is admirably suited for use as an electrical resistance element because the new alloy possesses not only the resistance to green rot corrosion which Alloy 798 has; but in addition, it has a very substantially longer life at high temperatures and a substantially greater resistance to carburization and sulfur pick-up as compared with not only Alloy 798, but alloys presently in commercial use for electrical resistance heating elements.

I claim:

1. An electrical resistance heating element formed of an alloy consisting essentially of 60% to 75% nickel,

18% to 22% chromium, 7% to 10% iron, 1.5% to 2.5% silicon, 1% to 2% cobalt and .25% to 1% columbium.

2. An alloy for use as an electrical resistance element which is characterized by its resistance to green rot corrosion, carburization and sulfur pick-up and by a long life at high temperatures, said alloy consisting essentially of 60% to 75% nickel, 18% to 22% chromium, 7% to 10% iron, 1.5% to 2.5% silicon, 1% to 2% cobalt and .25% to 1% columbium.

3. An alloy for use as an electrical resistance element which is characterized by its resistance to green rot corrosion, carburization and sulfur pick-up and by a long life at high temperatures, said alloy consisting essentially of about 70% nickel, 20% chromium, 8.3% iron and from 1% to 2% cobalt and .25% to 1% columbium.

4. An electrical resistance heating element formed of an alloy consisting essentially of 60% to 75% nickel, 18% to 22% chromium, 7% to 10% iron, 1% maximum manganese, 1.5% to 2.5% silicon, .15% maximum carbon, 1% to 2% cobalt and .25% to 1% columbium.

References Cited in the file of this patent

UNITED STATES PATENTS

2,008,862	Guetti	July 23, 1935
2,145,020	Becket et al.	Jan. 24, 1939
2,422,489	Kihlgren et al.	June 17, 1947
2,747,992	Hildebrand et al.	May 29, 1956

FOREIGN PATENTS

1,043,378	France	June 10, 1953
1,106,645	France	July 20, 1955