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CORROSION RESISTANT ALLOY

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4 Claims. (Cl. 148—11.5)

This invention relates to an alloy composition and to a process of treating same for the purpose of imparting desirable properties thereto. In particular the invention relates to a class of alloys consisting principally of a metal of the iron group, a lesser amount of a metal of the chromium group and still lesser amounts of beryllium with or without a small amount of copper.

It has been the inventor's aim when conceiving the present invention to develop an acid resistant alloy of high elastic properties, permitting its application to various chemical industries and processes where the article or part made of this alloy has to act as a spring.

Usually springs are made of heat treated steel, but this material does not possess acid resistant properties. On the other hand a number of alloys like high chromium iron, nickel-chromium, nickel-molybdenum etc. resist well the action of a number of mineral and organic acids but do not display the necessary elastic properties because, none of them can be hardened by heat treatment.

It has been discovered recently that nickel, iron, cobalt and copper can be hardened to a very large extent by alloying with beryllium and subjecting the alloys to a process of heat treatment. Such alloys however do not possess any particular corrosion resistance in comparison with the base metals forming their principal components. In addition, the amount of beryllium required to impart to the alloys a Brinell hardness of approximately 400, below which figure the elasticity is not nearly as good as obtainable in steel springs, equals 1.5 per cent at least. This high content of the very expensive beryllium imposes rather narrow limits for the commercial applications of such alloys.

The present inventor found, that by substituting up to 25 per cent of a metal of the chromium group, namely chromium or molybdenum and to a lesser degree of tungsten for the base metal of the binary beryllium alloys above mentioned, new alloys are being obtained which will resist a number of acids and which can be treated to yield satisfactory springs even when the amount of beryllium drops to 1.0 per cent.

Still less beryllium is required, when up to 10 per cent of copper is substituted for an equal amount of the base metal of such binary and ternary alloys. An alloy for instance of the composition: 15 per cent chromium, 10 per cent molybdenum, 8 per cent copper, 0.75 per cent beryllium and 66.25 per cent nickel develops in the heat treated state a hardness of 420 Brinell

and possesses a high resistance to the action of nitric acid and a good resistance toward hydrochloric acid.

However, even as little as 0.75 per cent beryllium added to any alloy will increase its price by \$1.50 per lb. at the present price of beryllium and it is difficult to expect, that anywhere in the near future, this added cost of manufacturing will drop to less than \$0.30. For this reason the present inventor developed the following method of adding beryllium to such alloys.

Beryllium chromate BeCrO_4 is first formed by any of the known methods of manufacturing chromates of metals—preferably by mixing together a known quantity of beryllium hydroxide with the equivalent amount of chromic acid in aqueous solution and evaporating to dryness.

This chromate is next mixed with a suitable amount of nickel monoxide and an equivalent amount of aluminum powder. One may use for instance 125 parts of beryllium chromate, 75 parts of nickel monoxide and 165 parts of powdered aluminum. A mixture of this kind will, when ignited, yield approximately 120 parts of a master alloy containing about 50 per cent nickel, about 41 per cent chromium and about 7 per cent beryllium, the balance being oxides and aluminum metal.

The master alloy so obtained forms a less expensive source of beryllium, than the metal obtainable by electrolysis and can be easily incorporated into a charge of materials intended to yield the desired composition upon melting and casting.

In the preparation of the master alloy the nickel monoxide may be replaced partly or completely by iron oxide, cobalt oxide or their mixtures to yield more complex master alloys if for some reasons a more complex composition is desired for the finished alloy.

The method of heat treatment by which alloys here described are rendered hard and elastic does not contain any innovations. It is the same as applied to duralumin, to copper-nickel-silicon alloys previously discovered by the same inventor etc. It consists in initially bringing the alloy into a state of nearly perfect solid solution. Such a state is reached by heating the alloy to temperatures above 900°C . but below the melting point. Optimum temperatures range from about 900° to 1190°C . Satisfactory heat treatment is obtained by heating the alloy up to 900 – 1000°C . for a period of 0.5–2 hours according to composition, drastic cooling from this temperature (quenching) and reheating to 250 – 500°C . At these lower

temperatures the alloy is held for 2-24 hours according to composition and to the degree of hardness desired. Any mechanical work entailing considerable shaping by pressure or tension is performed either in the hot state or previous to the final heat treatment if it has to be done in the cold state.

My claims are:

1. A corrosion resistant metal article comprising an alloy containing from about 1 to 20 per cent of iron, about 10 to 20 per cent of chromium, about 5 to 10 per cent of copper, about 0.5 to 1.5 per cent beryllium with a balance substantially nickel, said alloy having the hardness and elasticity produced by bringing the alloy into a state of solid solution by heating from about $\frac{1}{2}$ to 1 hour at temperatures above 900° C. but below the melting point of the alloy, followed by quenching and reheating from about 6 to 12 hours at temperatures ranging from about 250° to 600° C.

2. A corrosion resistant metal article comprising an alloy containing about 1 to 8 per cent of iron, about 10 to 18 per cent of molybdenum, about 5 to 10 per cent copper and from about 0.5 to 1.5 per cent of beryllium with a balance substantially nickel, said alloy having the hardness and elasticity produced by heating the alloy from about $\frac{1}{2}$ to 1 hour in the range of about 900° to 1100° C., followed by quenching and reheating

from about 6 to 12 hours at temperatures ranging from about 250° to 600° C.

3. A corrosion resistant metal article comprising an alloy containing about 10 per cent of molybdenum, about 15 per cent of chromium, about 8 per cent of copper and about 0.5 to 1.5 per cent of beryllium with a balance substantially nickel, said alloy having the hardness and elasticity produced by bringing the alloy into a state of solid solution by heating from about $\frac{1}{2}$ to 1 hour at temperatures above 900° C. but below the melting point of the alloy, followed by quenching and then by reheating from about 6 to 12 hours at temperatures ranging from about 250° to 600° C.

4. A corrosion resistant metal article comprising an alloy containing the following constituents in about the proportions by weight of from 1 to 20 per cent iron, 10 to 20 per cent of at least one metal of the chromium group, from 5 to 12 per cent of copper and from 0.5 to 1.5 per cent of beryllium with a balance substantially nickel, said alloy having the hardness and elasticity produced by bringing the alloy into a state of solid solution by heating from about $\frac{1}{2}$ to 1 hour at temperatures above 900° C. but below the melting point of the alloy, followed by quenching and by age-hardening at temperatures ranging from about 250° to 600° C.

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