UNITED STATES PATENT OFFICE.

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METAL ALLOY.

1,203,180. Specification of Letters Patent. Patented Oct. 31, 1916.

No Drawing. Original application filed October 17, 1914, Serial No. 867,076. Divided and this application filed February 2, 1915. Serial No. 5,606.

To all whom it may concern:

Be it known that I, THEODORE B. BRIX, a citizen of the United States, and a resident of Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Metal Alloys, of which the following is a specification.

My invention relates to alloys.

The alloy which is the subject matter of my invention has several highly valuable characteristics, and in its preferred form it may be designated as a nickel-chrome alloy, since the nickel-chrome content predominates.

This application is a division of my co-pending application for metal alloys, Serial Number 867,076, filed October 17, 1914.

I have found that an alloy comprising predominantly nickel or cobalt, the nickel or cobalt content being say not less than about 55% by weight, and one or more metals of the chromium group, such as chromium or chromium and tungsten or chromium and titanium, between 15 and 35%, with silicon not over 10%, which have been melted with one or more metals such as copper and manganese, to give fluidity to the alloy and render it homogeneous, has very valuable characteristics.

The preferred form of the alloy by actual test has been found to stand a very high degree of heat—about 3000° Fah., and to be dissolved only by hot akuaregia (nitro-hydrochloric acid). In its preferred form it is substantially if not entirely unaffected by other acids, thus rendering it highly valuable for use in making laboratory utensils, or other articles which must withstand a high temperature or be substantially unaffected by ordinary acids. I have also found that the alloy is hard and capable of taking a good edge and may be made malleable, and on account of these features it is highly useful for cutlery, tools and instruments generally. The alloy in some forms is also ductile.

I will first state the ingredients of the preferred form of the alloy, giving the relative proportions of each for the preferred form of the alloy, and their functions in the alloy. I will then point out by way of example some substitute ingredients that I have found to be satisfactory, and will then describe the preferred method of making the preferred form of the alloy, and will then particularly point out my invention in the appended claims.

The preferred form of the alloy contains nickel, chromium, copper, silicon, tungsten, aluminum and manganese (the aluminum appearing as a result of the manufacture of the alloy, as aluminum facilitates the manufacture, but it is mostly burned out and may be replaced by copper in producing or manufacturing even the preferred form of alloy, although for some uses of the alloy the presence of aluminum in the alloy may prove to give to it certain desirable features). This form of the alloy is made by reducing to a molten mass the following metals in the approximate proportions set forth: nickel, 60 to 75% by weight; chromium, 15 to 20% by weight; copper 5% by weight; silicon, 4% by weight; tungsten, 1 to 4% by weight; aluminum, 2% by weight, manganese-titanium ($\frac{2}{3}$ manganese), 3% by weight, or manganese 2% by weight, and boron 1% by weight. I have found that an alloy made from these metals in substantially the proportions given has the valuable characteristics of the alloy heretofore mentioned. The nickel and chromium are the main ingredients which, with the tungsten and the use of boron or titanium in the manufacture of the alloy, give the metal its high melting point, which may be varied by varying the proportions of tungsten and boron. Increase in the proportion of tungsten with the use of boron as a flux increases the melting point of the alloy. The silicon and chromium are the most important constituents giving the acid-resisting quality to the alloy. Silicon and tungsten give the alloy its property of hardness. When relatively small percentages of silicon and chromium are used, the alloy as stated, is ductile and malleable.

I have found that the temperature at which the alloy is poured regulates to a marked extent its ductility and malleability, and that the proportions of the nickel and chromium also affect these characteristics; an increase of nickel and a reduction of chromium increases the malleability and ductility, and vice versa.

I have found that for some uses of the alloy cobalt may be substituted for the nickel, but when such a substitution is made

the alloy is not so acid-resisting, as it will not withstand hydrochloric acid. I have also found that for some uses of the alloy, another suitable metal of the tungsten group, such as titanium, may be substituted for the tungsten ingredient of the preferred form of the alloy. With this substitution the alloy is homogeneous and ductile and withstands the ordinary acids, but is lacking in hardness. I have also found that inasmuch as copper and aluminum are used principally to assist in the melting of the alloy and to give it its homogeneous character, the aluminum content may be replaced by an equivalent amount of copper or other suitable metal of low melting point having the same effect on the contents of the alloy as copper. In such a case it is preferable to substitute for the aluminum substantially the same amount of copper in addition to that usually used with the aluminum. The result of such substitution seems to give no marked or different characteristic than when both copper and aluminum are used, but the use of aluminum with the copper is preferable from the standpoint of manufacture, since it facilitates the melting of the metals. Some of the copper and a considerable amount of the aluminum are burned out in the manufacture of the alloy; and where the small amount of titanium is used with the manganese, very little if any titanium seems to be retained in the alloy; but where titanium is substituted for tungsten, as above stated, of course a very appreciable percentage remains in the alloy. I have also found that the respective ingredients of the contents may be varied for the purpose of changing the characteristics of the alloy in one or another particular. As far as I have been able to ascertain, the nickel or cobalt content should be between 55 and 80% by weight, chromium between 10 and 25% by weight, copper not over 6% by weight, aluminum not over 4% by weight, tungsten or titanium not over 8% by weight, silicon not over 10% by weight, manganese not over 6% by weight, and titanium or boron when used as a flux with manganese, not over 5% by weight; and the combined nickel and chromium content or cobalt-chromium content should not exceed 90% by weight. It will, of course, be understood, however, that rapid strides are being made in the manufacture of alloys, both in the process of melting the constituents and in rolling or forging the alloys, and that with these improved methods of manufacture it is possible that the respective ingredients of the alloy may be further varied while retaining certain valuable characteristics thereof.

By way of illustrating the manner in which the characteristics of the alloy are affected by varying the different ingredients, I will give a few examples of the alloy in which the percentages of certain ingredients were varied. For example, the alloy made from nickel 61%, chromium 20%, copper 5%, aluminum 3%, tungsten 4%, silicon 4% and manganese-titanium (⅔ manganese) 3%, produced an alloy which was very hard, substantially resistant to all acids other than nitro-hydrochloric acid and which took a good edge and was somewhat malleable. Whereas an alloy made from nickel 72% chromium 16%, copper 4%, aluminum 1%, silicon 4% and manganese-titanium (⅔ manganese) 3%, retains its acid-resisting property, but is very ductile and capable of being rolled and drawn into wire; and an alloy made with nickel 68%, chromium 15%, silicon 8%, copper 4%, tungsten 1%, aluminum 1%, and manganese-titanium (⅔ manganese) 3%, has the characteristic of great hardness but is less ductile than alloy example #2. The alloy made with nickel 65%, chromium 22%, silicon 4% and the rest of the ingredients as given in the last example (#3), was not as hard as the alloy #3 but was harder than the alloy #2 and had marked acid-resisting properties.

In manufacturing the alloy according to the preferred method, I place the whole of the tungsten and half of the chromium in an electric furnace, the temperature of which is approximately 2800° to 3400° Fah., and heat them until the mixture comes to a semi-molten or pasty consistency, whereupon the other half of the chromium is placed in the furnace and the whole is melted. As the compound in the electric furnace is brought to the melting point, and just before it is melted so as to assist in melting it, a small percentage—for example, about 5% of the nickel is added, and the whole thoroughly melted. Simultaneously with the melting of these metals in the electric furnace, the balance of the nickel, the copper and the silicon are placed in another furnace such, for example, as a gas furnace, the temperature of which is approximately 2800° Fah., and melted. While the compound in the gas furnace is being brought to the melting point, the aluminum is gradually added in small quantities. The addition of the aluminum in this manner acts effectively as a reducing agent on the other metals in the furnace, combining with the oxids, and, I believe, more particularly with the oxids of the copper to assist in reducing the same. When the constituents in both furnaces have been melted, the contents of the gas furnace are emptied into the electric furnace and the whole stirred, whereupon the manganese and titanium or manganese and boron are added to the whole and stirred, the heat being kept up until the entire mixture is thoroughly melted, the time for which I find in practice to consume about five minutes from the time the man-

ganese was added. The different contents are all used in the metallic form. The manganese and titanium or manganese and boron act as a flux assisting in melting the alloy, these metals being de-oxidizing agents, acting to clarify the solution and aiding in the melting of the metals. I believe that the titanium combines with the oxygen from the other metals, or with the oxids and sulfids, which latter are present as impurities in one or more of the constituents, and thus aids in reducing these metals and purifying the alloy. The manganese not only acts as a flux and reducing agent, but as a constituent in the alloy. The boron or titanium, however, either of which may be used as a flux with the manganese, seems to completely disappear in the process of melting the alloy, since so far I have been unable to find any traces of them in the resulting product. Their use, however, in the manufacture of the product plays a highly important part, since I have found that the alloy made without them is of a coarser and less homogeneous structure. I have also found that some of the aluminum is volatilized or otherwise disappears during the melting operation, although a perceptible amount of it remains in the alloy. In melting the alloy, such fluxes as Paris green and niter, and other well known fluxes, may be made use of, to assist in reducing the metals. I have found that an alloy made according to the above process and containing the above ingredients in substantially the proportions set forth, is soluble in hot aquaregia (nitro-hydrochloric acid) and is slightly affected by cold aquaregia, although not soluble therein, but is substantially unaffected by the ordinary acids.

The alloy may be made into knives or surgical instruments, and has been found to take and hold a sharp edge. The alloy can be used in laboratory and other uses where receptacles or other articles are required having acid-resisting qualities and capable of standing high temperatures.

It will be obvious to those skilled in the art, after understanding my invention, that modifications and substitutions of equivalents may be made in the alloy without departing from the spirit or scope of my invention, and that my invention is not to be limited to any particular method of making the alloy, and I aim in the appended claims to cover all modifications, substitutions and changes within the scope of my invention.

Where in the specification and claims I use the expression "one or more metals of the nickel group such as nickel", I do not wish to be understood as meaning any other metals of this group than nickel or cobalt. They are the only two metals, as far as I now know, that have sufficiently like characteristics to render them suitable for the main constituent of the alloy according to my invention, and I use this expression for lack of any better term that would include both of these metals; and where I use, in the appended claims, the word "nickel" as distinguished from the above-mentioned expression, I wish to be understood as meaning nickel, to the exclusion of cobalt; also, where I use the expression, in the appended claims, "non-ferrous metal alloy", I mean an alloy containing substantially no iron; that is, no iron in substantial amounts, such as would change the characteristic of the alloy. I do not wish to be understood as meaning any other metals than nickel and cobalt, and where in the appended claims I refer to the percentages of the different ingredients, I wish to be understood as meaning percentages by weight.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A metal alloy containing one or more metals of the nickel group such as nickel not under 55%, one or more metals of the chromium group such as chromium not over 30%, silicon not over 10%, and one or more metals that will act on the contents of the alloy to assist in melting the same to render the alloy homogeneous, such as copper.

2. A metal alloy containing one or more metals of the nickel group such as nickel not under 55%, one or more metals of the chromium group such as chromium not over 30%, silicon, and one or more metals that will act on the contents of the alloy to assist in melting the same to render the alloy homogeneous, such as copper.

3. A metal alloy containing one or more metals of the nickel group such as nickel not under 55%, one or more metals of the chromium group such as chromium not over 30%, silicon, and one or more metals that will act on the contents of the alloy to assist in melting the same to render the alloy homogeneous, including copper.

4. A non-ferrous metal alloy containing one or more metals of the nickel group such as nickel not under 55%, one or more metals of the chromium group such as chromium not over 30%, silicon not over 10%, and one or more metals that will act on the contents of the alloy to assist in melting the same to render the alloy homogeneous, such as copper.

5. A non-ferrous metal alloy composed predominantly of one or more metals of the nickel group such as nickel and one or more metals of the chromium group such as chromium, and containing silicon, and one or more metals that will act on the contents of the alloy to assist in melting the same to render the alloy homogeneous, such as copper.

6. A metal alloy containing one or more metals of the nickel group such as nickel not under 55%, chromium 10 to 25%, one or more other metals of the chromium group such as tungsten not over 15%, and copper, silicon and manganese, not over 16%.

7. A metal alloy containing one or more metals of the nickel group such as nickel 55 to 80%, chromium 10 to 25%, one or more other metals of the chromium group such as tungsten not over 8%, silicon not over 10%, copper not over 6%, and manganese not over 6%.

8. An alloy containing a metal of the nickel group such as nickel, together with chromium, not under 65%, one or more other metals of the chromium group not over 15%, silicon not over 10%, and at least one other metal having a lower melting point than nickel and which will assist in melting the contents of the alloy.

9. An alloy containing a metal of the nickel group such as nickel, together with chromium, not under 70%, one or more other metals of the chromium group not over 15%, silicon not over 10% and copper not over 6%, said ingredients having been alloyed by the aid of a metal such as manganese.

10. An alloy containing a metal of the nickel group such as nickel, together with one or more metals of the chromium group, such as chromium, not under 75%, silicon, copper and manganese.

11. An alloy containing nickel and one or more metals of the chromium group, such as chromium, not under 65%, silicon, copper and manganese.

12. A metal alloy containing one or more metals of the nickel group such as nickel, together with chromium, from 75 to 90%, silicon, one or more other metals of the chromium group and one or more metals, including copper, which will aid in the alloying of the constituents.

13. A metal alloy containing one or more metals of the nickel group such as nickel, together with chromium, from 65 to 90%, copper, silicon and tungsten, said ingredients having been alloyed with the aid of manganese.

14. A metal alloy containing nickel, together with chromium, from 80 to 90%, copper, silicon, one or more other metals of the chromium group and one or more metals which will aid in melting the constituents, such as copper.

15. A metal alloy containing one or more metals of the nickel group such as nickel, together with one or more metals of the chromium group such as chromium, from 75% to 90%, silicon, and one or more metals which will aid in melting the constituents, such as copper.

16. A non-ferrous metal alloy containing nickel together with chromium from 80% to 90%, silicon, one or more metals which will aid in melting the constituents, such as copper, and one or more other metals of the chromium group.

17. A metal alloy containing one or more metals of the nickel group such as nickel, together with chromium, from 80 to 90%, copper, silicon, tungsten and manganese.

18. A metal alloy containing one or more metals of the nickel group such as nickel, together with chromium, from 80 to 90%, copper, aluminum, silicon, tungsten and manganese.

19. An alloy containing nickel and chromium, not under 75%, one or more other metals of the chromium group, not over 15%, silicon not over 10%, and one or more metals which will aid in melting the constituents, including copper not over 6%.

20. A metal alloy containing nickel not under 55%, one or more metals of the chromium group such as chromium not over 30%, and in addition tungsten, and silicon, said constituents having been alloyed by the use of one or more metals such as copper, to assist in melting the same and render the alloy homogeneous.

21. A metal alloy containing one or more metals of the nickel group such as nickel, from 60 to 75%, chromium from 15 to 25%, tungsten not over 5%, silicon from 2 to 8%, copper not over 6%, and manganese not over 5%.

22. A metal alloy containing one or more metals of the nickel group such as nickel from 60% to 75%, one or more metals of the chromium group such as chromium from 12% to 25%, silicon, and one or more metals which will aid in melting the constituents, including copper.

23. A non-ferrous metal alloy containing one or more metals of the nickel group such as nickel, from 60% to 75%, chromium from 12% to 25%, and one or more other metals of the chromium group such as tungsten, silicon, and one or more metals which will aid in melting the constituents, such as copper.

24. A metal alloy containing one or more metals of the nickel group such as nickel, from 60 to 70%, chromium from 15 to 25%, tungsten from 1 to 5%, silicon from 2 to 10% and one or more metals which will aid in melting the constituents, including copper from 3 to 6%.

25. A metal alloy containing one or more metals of the nickel group such as nickel, from 60 to 70%, chromium from 15 to 25%, copper from 3 to 6%, tungsten from 1 to 5%, silicon from 2 to 10%, and manganese approximately 2%.

26. A metal alloy containing nickel from 60 to 70%, chromium from 13 to 22%, tungsten, silicon, and one or more metals

which will aid in melting the constituents, such as copper.

27. A metal alloy containing nickel from 60 to 70%, chromium from 13 to 22%, tungsten not over 4%, silicon from 3 to 6%, and one or more metals which will aid in melting the constituents, including copper from 1 to 4% and aluminum not over 4%.

28. A non-ferrous metal alloy containing one or more metals of the nickel group such as nickel not under 55%, one or more metals of the chromium group such as chromium not over 30%, and silicon, said constituents having been alloyed by the use of one or more metals such as copper, to assist in melting the same and rendering the alloy homogeneous.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

THEODORE B. BRIX.

Witnesses:

OTTO A. STIEFEL,

FREDERICK O. RUNYON.