Patented Dec. 1, 1953

2,661,285

UNITED STATES PATENT OFFICE

2,661,285

NONFERROUS ALLOY

Max Gorschalki, Altadena, Calif.

No Drawing. Application February 25, 1950, Serial No. 146,387

9 Claims. (Cl. 75—171)

1

This invention relates to alloys containing nickel, chromium, manganese and molybdenum, and particularly to such alloys in which the nickel and chromium contents predominate.

An object of the invention is to provide such a stainless non-ferrous alloy characterized by high tensile strength, and resistance to corrosive attack by such substances as acid, alkali, sea water and corrosive gases. A related object is to provide such an alloy which is highly resistant to wear. Other objects are to provide an alloy capable of high surface polish and high electrical resistivity.

There have heretofore been proposed non-ferrous alloys composed principally of nickel and chromium and there have ever been proposed nickel-chromium alloys containing molybdenum. None of these non-ferrous alloys, however, have been characterized by exceptionally high tensile strength, for example, beyond 95,000 lbs. per square inch. In accordance with my invention, I can provide an alloy capable of a tensile strength in the order of 150,000 lbs. per square inch; and I have been able to do this by my discovery that the addition to a nickel-chromium alloy of both manganese and molybdenum in proper proportions can markedly increase the tensile strength, as well as the wear resistance, without undue brittleness.

While molybdenum and manganese have heretofore been used separately to some extent in metal alloys, particularly ferrous metal alloys, for one purpose or another, the use of both molybdenum and manganese in a nickel-chromium base alloy has never heretofore been used in proportions which make them a significant part of the completed alloy. In the course of my experiments, I have found that the addition of molybdenum or of manganese separately from each other in a nickel-chromium alloy does not increase the tensile strength appreciably beyond 95,000 lbs. per square inch, regardless of amounts used. However, when I added both molybdenum and manganese in proper proportions to the nickel-chromium alloys, I experienced the unusual result that the tensile strength could thereby be almost doubled. The presence of manganese in the proportion of about 2 to 4% by weight of the alloy and of molybdenum in the proportion of about ½ to 2% by weight of the alloy, can increase the tensile strength of a nickel-chromium alloy from about 79,700 to about 153,000 lbs. per square inch.

The inclusion of the manganese benefits the alloy by increasing its malleability and toughness

2

as well as providing the extraordinarily high tensile strength in combination with the molybdenum. The molybdenum in addition to producing the great tensile strength in company with the manganese, provides for the alloy the desirable properties of increased ductility and fatigue resistance.

Increasing either the manganese or the molybdenum, or both, substantially above 4% or 2%, respectively, would create an alloy of undue brittleness; and decreasing the manganese or molybdenum, or both, substantially below 2% and ½%, respectively, would markedly decrease the tensile strength.

I have found that many other desirable characteristics can be introduced or improved in my novel alloy by the addition of proper amounts of other substances without seriously impairing the extremely high tensile strength. Such additives are referred to herein as being not subversive of the characteristic of the nickel-chromium-manganese-molybdenum alloy mentioned above. I have found, for example, that by adding from about 2 to 4% by weight of silver to the alloy, the resistance to corrosion by sea water, and also the malleability of the alloy, can be markedly increased. Substantially less than 2% silver fails to afford very great corrosion resistance; and any substantial excess beyond 4% silver does not go into solution, and will merely remain present as silver inclusions in the alloy. In many cases, an excess of as much as about 2% of silver (that is, a total silver content of about 6%) can be tolerated without serious adverse effect due to the inclusions.

Another substance which it is very desirable to use when making the alloy, is boron, which is desirable for its highly deoxidizing properties; and this is preferably used in the form boronic copper. The grade known commercially as "No. 4 boronic copper F 3½" is preferred; and its presence contributes considerably to the corrosion resistance.

A further especially desirable addition is a small amount of aluminum, for example, in the order of 1% by weight of the alloy, which it is desired to add to the molten mixture for its degasifying properties, as well as for its attribute of increasing the corrosion resistance of the finished alloy to acids. While the aluminum may possibly be dispensed with in some cases, its omission will increase the risk of gas pocket and blowhole formation in the alloy, and there will seldom if ever be any reason for omitting the aluminum. Up to about 4% of aluminum could be used ef-

fectively. It goes off as a gas during the melting, carrying other gases off with it. Actually the amount of the aluminum can be increased even beyond 4% without harmful result, but there would be no advantage in doing it, as it would simply increase gas evolution beyond any useful amount. In using up to about 1% aluminum, nearly all of it goes off as gas. Using substantially more than 1% aluminum will leave some aluminum in the alloy, which may have beneficial effect in increasing corrosion resistance.

While the proportions of the various ingredients set forth above should be maintained within the proper limits to provide a suitable alloy, it should be recognized that more or less variation in the relative proportions is permissible, and even desirable for bringing out special properties in the finished product, for particular purposes, as will be more fully set forth hereinbelow.

I have discovered that the proportions of the ingredients may range as follows. Considering an alloy containing only nickel, chromium, manganese and molybdenum, these may range in the following relative proportions, in which the percentages are given by weight, based on the total weight of these four ingredients:

	Percent
Nickel	69 to 80
Chromium	16 to 25
Manganese	2 to 4
Molybdenum	½ to 2

The following is a typical example of an alloy composition consisting of these four ingredients:

Example I

	Percent
Nickel	74
Chromium	23
Manganese	2½
Molybdenum	½

The following two examples show specific variations within the permissible range:

Example II

	Percent
Nickel	80
Chromium	16.5
Manganese	2
Molybdenum	1½

Example III

	Percent
Nickel	69
Chromium	25
Manganese	4
Molybdenum	2

In all these examples, the percentages are given by weight, based on the total weight of the named ingredients. In Example II, the alloy will be more ductile with good fatigue resistance due to the molybdenum content having been increased 1%; the 2% of manganese was found to lower the malleability. In Example III, the alloy will be more malleable and tough, due to the manganese content having been increased by 1½%. The 1½% increase in molybdenum was found to give higher fatigue resistance, ductility and strength, than in Example I.

As has already been explained, it is preferable to add a small amount of boron, preferably in the form of boronic copper, and also a small amount of aluminum. The addition of aluminum should be in the order of about 1% by weight; and this addition can be made in any of the foregoing three examples, simply by adding in the alloys of these examples an amount of aluminum equal to about one percent by weight, considering the boronic substance, if any, to be present in an amount stated below, and the nickel, chromium, molybdenum and manganese to add up to the balance in the relative proportions given in the above-mentioned range or examples. The aluminum may be added to produce its advantage regardless of whether the boron or boron compound is present.

When the boron compound is added, as will ordinarily be preferred, this can be added in the form of boronic copper in the order of about 2% by weight, considering the aluminum, if any, to be about 1% by weight, and the nickel, chromium, molybdenum and manganese to add up to the balance, in the relative proportions given in the above-mentioned range or examples.

It is possible to use boron in free form instead of in the form of boronic copper, but the use of free boron will usually be less desirable than the boronic copper because of greater violence of action, and its tendency to produce a glassy hardness of the alloy.

Boronic copper is a well known commodity; it is ordinarily a pure copper, such as electrolytic copper, impregnated with boronic gases. Grade No. 3 Boronic Copper Alloy, which is the preferred grade, is a commercial product. There are several grades of boronic copper, which differ somewhat from each other in the proportion of boron in the copper.

Four boronic-copper alloys were experimented with to determine the relative effectiveness of the several grades; and for this purpose boronic-copper alloys designated as grades #2, #3, #4, "F3½" and #5 "S" were used. In this system of grading, the proportion of boron relative to the copper in the alloy increases with the higher numbers. Thus, the #1 grade has the least boron, and the #5 "S" grade has the most boron.

It was found that when using the #2 grade, there resulted in the finished metal, a considerable number of blow holes and gas pockets, and the fluxing was not as good as in the higher numbered grades. With the use of the #3 grade, boronic-copper alloy, excellent fluxing was experienced and there were no blow holes or gas pockets in the finished product. When using the #4 boronic copper "F3½," there was experienced good fluxing and freedom from blow holes and gas pockets; although in this case, the tensile strength of the finished metal was slightly lower than when using the #3 grade boronic copper. When using the #5 boronic-copper alloy "S," there was freedom from blow holes and gas pockets, but considerably more brittleness was present in the finished metal. From this work, it follows that the intermediate grades, #3 and #4 "F3½" will ordinarily be preferred, with the #3 grade having the preference.

As noted above, the addition of silver as an additive will increase the corrosion resistance and the malleability; and the addition of silver may be in an amount of about 2 to 4% by weight based on the weight of the alloys set up in Examples I, II and III. A particularly good amount of silver for a good malleable alloy is about 3% by weight of the alloy, considering the boronic substance and/or aluminum, if any, to be present in amounts stated above, and the nickel, chromium, molybdenum and manganese to add up to the balance in the relative proportions stated in the above range or examples. When the alloy is composed of all these substances, examples of suit-

able relative proportions are as follows; the parts being by weight:

	Example IV	Example V	Example VI
	Percent	*Percent*	*Percent*
Nickel	71	70	69
Chromium	19	20	17
Manganese	2½	2	4
Silver	2	2½	4
Boronic copper (Grade No. 4, F3½)	3	1	2½
Molybdenum	½	1½	2
Aluminum	2	3	1½
	100	100	100

The following is a typical example of a relatively "soft" alloy which I can make according to my invention:

Example VII

	Percent	
Nickel	72	Shot form.
Chromium	18	Metallic, pea size.
Manganese	3	Powder form.
Silver	3	Shot form.
Boronic copper	2	Shot form.
Molybdenum	1	Powder form.
Aluminum	1	Thin strips cut up to bits, or shot form.
	100	

In all of the foregoing examples, the nickel, silver and boronic copper may be introduced into the crucible or furnace in shot form; the chromium may be in pea size metallic form; the manganese and molybdenum may be used in powder form and the aluminum may be in the form of thin cut up strips or pieces.

The alloy can be made in accordance with the following procedure. I use a furnace, preferably an induction furnace, capable of being raised to a temperature of at least 3000° F.; and I first bring the furnace to a temperature of about 2000° F. I then place in the furnace a crucible containing all of the nickel, chromium and molybdenum which is to be used, and also one-half of all the boronic copper, when boronic copper is used. I have found that this preheating of the furnace to about 2000° F. before placing in it the crucible containing the ingredients will avoid the low oxidizing temperatures of nickel. The temperature is then increased above 2000° F. When the temperature reaches about 2600° F., it will be observed that the contents have assumed a quasi-liquid form; and when this is observed, the remaining one-half of the boronic copper is added and stirred up into the mass. The temperature will then be gradually raised to about 2700° F., whereupon, such silver as is to be used will be added; and the mass will be stirred again. Then the temperature will be brought up to about 2800° F., whereupon the manganese will be added, the mass being again stirred upon this addition.

Where aluminum is used, as is ordinarily preferable to prevent the formation of gas pockets and blow holes in the product, this will be added after the temperature has been maintained for a few minutes at about 2800° F., after the addition of the manganese; and the aluminum will similarly be thoroughly stirred into the liquid mass. After the aluminum has been completely added, the temperature will be allowed to decrease to about 2700° F., whereupon the liquid mass will be poured into molds which have been heated to about 600° F.; and the molds containing the alloy will then be allowed to cool down to room temperature. Such molds can be made of a suitable substance such as cast iron or graphite.

It will be recognized that by my invention, I have provided an unusually strong non-ferrous alloy, which by proper use or non-use of the additives can be made soft or ductile, as desired, or on the other hand, can be made relatively hard. Furthermore, the alloy is resistant to acid and corrosion. Moreover, by proper variation of the proportions of the ingredients, it is possible to produce alloys of different grades of hardness, electrical conductivity and ductility. The softer grades of the alloy can be rolled into flats, or other desired shapes, or can be drawn into wire. Furthermore, the alloy can be soft soldered, brass soldered, gold soldered and electrically welded.

I claim:

1. A stainless non-ferrous alloy having the characteristics of higher tensile strength than nickel-chromium alloys and of resistance to corrosion to acid, alkali, sea water and corrosive gases, said alloy consisting of nickel, chromium, manganese and molybdenum in the approximate proportions of 69% to 80% by weight of nickel, 16% to 25% by weight of chromium, 2% to 4% by weight of manganese and about ½% to 2% by weight of molybdenum, based on the total weight of the nickel, chromium, manganese and molybdenum in the alloy, and free of material subversive of said characteristics.

2. A non-ferrous alloy having the characteristics of higher tensile strength than nickel-chromium alloys and of resistance to corrosion to acid, alkali, sea water and corrosive gases, said alloy consisting of nickel, chromium, manganese, molybdenum, and silver, the nickel being present in an amount of 69% to 80% by weight, the chromium being present in an amount of about 16% to 25% by weight, the manganese being present in an amount of about 2% to 4% by weight, and the molybdenum being present in amount of about ½% to 2% by weight, based on the total weight of the nickel, chromium, manganese and molybdenum in the alloy, and the silver being present in an amount of about 2% to 6% by weight, based on the total weight of the nickel, chromium, manganese, molybdenum and silver.

3. A non-ferrous alloy having the characteristics of higher tensile strength than nickel-chromium alloys and of resistance to corrosion to acid, alkali, sea water and corrosive gases, said alloy consisting of nickel, chromium, manganese, molybdenum, and aluminum, the nickel being present in an amount of 69% to 80% by weight, the chromium being present in an amount of about 16% to 25% by weight, the manganese being present in an amount of about 2% to 4% by weight, and the molybdenum being present in an amount of about ½% to 2% by weight, based on the total weight of the nickel, chromium, manganese and molybdenum in the alloy, and the aluminum being present in an amount of approximately 1% by weight based on the total weight of the nickel, chromium, manganese, molybdenum and aluminum.

4. A non-ferrous alloy having the characteristics of higher tensile strength than nickel-chromium alloys and of resistance to corrosion to acid, alkali, sea water and corrosive gases, said alloy consisting of nickel, chromium, manganese and molybdenum in the approximate proportions of 69% to 80% by weight of nickel, 16% to 25% by weight of chromium, 2% to 4% by weight of manganese and about ½% to 2% by weight of molybdenum, based on the total

weight of the nickel, chromium, manganese and molybdenum in the alloy, said alloy containing a minor but significant amount of boron, and free of material subversive of said characteristics.

5. A non-ferrous alloy having the characteristics of higher tensile strength than nickel-chromium alloys and of resistance to corrosion to acid, alkali, sea water and corrosive gases, said alloy consisting of nickel, chromium, manganese, molybdenum, silver and boron, the nickel, chromium, manganese and molybdenum being in the approximate relative proportion of 69% to 80% by weight of nickel, 16% to 25% by weight of chromium, 2% to 4% by weight of manganese, ½% to 2% by weight of molybdenum, and the silver being present in an amount of about 2% to 6% by weight of the total alloy and the boron being present in a minor but significant amount.

6. A non-ferrous alloy having the characteristics of higher tensile strength than nickel-chromium alloys and of resistance to corrosion to acid, alkali, sea water and corrosive gases, said alloy consisting of, by weight, about 70% nickel, about 20% chromium, about 2% manganese, about 2½% silver, about 1½% molybdenum and about 3% aluminum, and such remainder as may exist being not subversive of said characteristics.

7. A non-ferrous nickel-chromium-manganese-molybdenum metal alloy having the characteristics of higher tensile strength than nickel-chromium alloy and being resistant to corrosion by acid, alkali, sea water and corrosive gases, said alloy consisting of nickel in amounts ranging from about 69% to 80% by weight, chromium in amounts ranging from about 16% to 25% by weight, manganese in amounts ranging from about 2% to 4% by weight, and molybdenum in amounts ranging from about ½% to 2% by weight, based on the total weight of the nickel-chromium-manganese and molybdenum in the alloy, such remainder as may exist being not subversive of the said characteristics.

8. A corrosion-resistant, non-ferrous nickel-chromium-manganese-molybdenum metal alloy having the characteristics of higher tensile strength than a nickel-chromium alloy, and of being resistant to corrosion by acid, alkali, sea water and corrosive gases, said alloy consisting of nickel in amounts ranging from about 69% to 80% by weight, chromium in amounts ranging from about 16% to 25% by weight, manganese in amounts ranging from about 2% to 4% by weight, and molybdenum in amounts ranging from about ½% to 2% by weight, based on the total weight of the nickel-chromium-manganese and molybdenum in the alloy, the remainder being material not subversive of the said characteristics, including silver in an amount of about 2% to 6% by weight, based on the total weight of the nickel, chromium, manganese, molybdenum and silver.

9. A non-ferrous nickel-chromium-manganese-molybdenum metal alloy having the characteristics of higher tensile strength than a nickel-chromium alloy and of being resistant to corrosion by acid, alkali, sea water and corrosive gases, said alloy consisting of nickel in amounts ranging from about 69% to 80% by weight, chromium in amounts ranging from about 16% to 25% by weight, manganese in amounts ranging from about 2% to 4% by weight, and molybdenum in amounts ranging from about ½% to 2% by weight, based on the total weight of the nickel-chromium-manganese and molybdenum in the alloy, the remainder being material not subversive of the said characteristics, including boron in a minor but significant amount .

MAX GORSCHALKI.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,115,239	Parr	Oct. 27, 1914
1,489,166	Chevenard	Apr. 1, 1924
1,572,996	Girin	Feb. 16, 1926
2,480,432	Allen	Aug. 30, 1949

FOREIGN PATENTS

Number	Country	Date
26,940	Great Britain	1907
354,765	Great Britain	Aug. 12, 1931