

UNITED STATES PATENT OFFICE

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CORROSION RESISTANT ALLOYS

No Drawing.

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My invention relates to corrosion resistant alloys and particularly to an alloy of molybdenum, nickel, chromium and iron, with various added constituents. An object of my invention is to produce an alloy having high resistance to most of the acids, either hot or cold, concentrated or diluted, as well as to corrosive vapors and such like agents. Another object of my invention is to produce a corrosion resistant alloy adapted to use in the cast form, which, without working or heat treating, shows a high corrosion resistance as cast, and which is also sufficiently soft to be machined readily.

It has been proposed to utilize alloys of molybdenum, nickel, chromium and iron as corrosion resistant materials. These alloys, however, have been found unsatisfactory for various reasons, particularly because of the fact that they did not show a satisfactory resistance to most of the corrosive liquids, and because of the fact that an elaborate heat treatment was required to prepare them for use.

By my invention I have produced a new and useful corrosion resistant alloy which shows a very high resistance to most of the common commercial substances which show corrosive tendencies.

Previous attempts to prepare alloys of molybdenum, nickel, and other substances have included, in the alloy composition, a substantial proportion of carbon ranging from 1.5% to 2%, which carbon was then very elaborately treated in the alloy, to convert it to the carbide form with the expectation that the presence of such carbide carbon would result in an increase in corrosion resistance. I find, however, that such is not the case and that a much superior corrosion resistance is obtained in such alloys by keeping the carbon content to the lowest possible value, below about 0.5% in any case, and preferably below 0.2%. When the carbon is kept to these low values no mechanical working or heat treating is necessary to obtain the maximum corrosion resistance in the alloy.

In the preparation of the alloy of my invention I may melt together, in the usual

way, the desired constituents in the proportions indicated in the following table:

	Range	Preferred range	Preferred composition	
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	
Molybdenum.....	10 to 40	15 to 25	20	55
Chromium.....	5 to 25	10 to 20	14	
Iron.....	5 to 25	5 to 15	8	
Manganese.....	0.1 to 2.5	0.1 to 1.5	.25 to 1	
Silicon.....	Not over 1	Not over 1	.25 to 1	
Carbon.....	Not over 0.6	Not over 0.3	Not over 0.2	60
Vanadium.....	.01 to 0.5	.01 to 0.5	.01 to 0.5	
Nickel.....	Remainder	Remainder	Remainder	

The first column indicates the maximum range of constituents which will produce a suitable alloy. The second column shows the range of constituents which will produce a thoroughly satisfactory and high grade alloy for general use and the third column shows the composition which I have found most satisfactory. It may be further noted that the proportions of the relative constituents will usually be so balanced that the nickel lies at 40% or higher, and lower than 40% only in special instances. The alloy within these composition ranges is soft enough to be machined without difficulty and is susceptible to a moderate amount of forging or rolling at suitable temperatures. The tensile strength is found to be in the neighborhood of 60,000 pounds per square inch with a small amount of elongation before rupturing. The alloy shows no tendency toward brittleness.

It may be noted that the inclusion of a small percentage of manganese is indicated; this is found to be of assistance in avoiding difficulty from any traces of sulphur derived, for example, from the molybdenum. The presence of silicon is indicated because of the fact that various of the commercial raw materials contain a small portion of silicon which appears in the finished alloy. The silicon is not necessary, but is not harmful if the total quantity is kept low. A small proportion of vanadium is desirable, both because of its function as a deoxidizer and also because of the production of a direct gain in acid resistance.

The alloy of my invention as above described shows a high and useful acid resistance.

The corrosion resistance of the alloy of my invention may be increased to a still higher value by the inclusion of certain proportions of tungsten, which is of particular value in obtaining the maximum possible resistance to nitric acid without sacrificing the resistance to hydrochloric, sulphuric and other acids. The alloy may be made in the usual way with a composition as indicated by the following table:

	Range	Preferred range	Preferred composition
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Molybdenum.....	10 to 40	15 to 24	17
Tungsten.....	1 to 20	1 to 10	5
Chromium.....	5 to 25	10 to 20	13
Iron.....	1 to 25	1 to 15	6
Manganese.....	0.1 to 2.5	0.1 to 1.5	.25 to 1
Silicon.....	Not over 1	Not over 1	.25 to 1
Carbon.....	Not over 0.6	Not over 0.3	Not over 0.2
Vanadium.....	0.1 to 0.5	.01 to 0.5	.01 to 0.5
Nickel.....	Remainder	Remainder	Remainder

This table, in common with that previously given, shows the maximum range of useful composition, the most suitable ranges of composition and the most desirable composition. It may be noted that a proportion of tungsten is included, which replaces a part of the molybdenum, a part of the chromium and a part of the iron. It may be noted that manganese, silicon and vanadium are included as in the first described alloy and that the same low values of carbon are specified, for the same reason. This alloy, while not brittle, is not adapted to rolling or forging but is desirably used in the cast state, although it is sufficiently soft to be readily machined.

By my invention I have thus produced a plurality of corrosion resistant alloys containing principally molybdenum, chromium, nickel and iron, in which a new and useful degree of corrosion resistance is obtained by limiting the carbon content to a particular value. My invention likewise includes the proportions of the associated metals and the inclusion of tungsten with a suitable proportion of other metals.

The alloy of my invention is particularly desirable in the total absence of carbon but because of the high cost and commercial difficulty of obtaining and mixing carbon free metals, I prefer to permit the inclusion of a definite but very small proportion of carbon.

While I have shown but a limited number of embodiments of the alloy of my invention, it is adapted to still other modifications therefrom without departure from the spirit thereof and it is desirable therefore that only such limitations be applied to the appended claims as are stated therein or are required by the prior art.

I claim as my invention:

1. An alloy comprising approximately molybdenum 20%, chromium 14%, iron 8%, manganese 0.75%, silicon 0.75%, carbon less

than 0.2%, vanadium 0.03%, and the remainder principally nickel.

2. An alloy comprising approximately molybdenum 17%, tungsten 5%, chromium 13%, iron 6%, manganese 1%, silicon 1%, vanadium 0.5%, carbon not over 0.2%, and the remainder principally nickel.

3. An alloy comprising molybdenum 15% to 25%, chromium 10% to 20%, iron 5% to 15%, tungsten approximately 5%, an appreciable amount of carbon but not over 0.2%, and the remainder principally nickel, at least 40% of nickel being present.

In testimony whereof, I affix my signature.

RUSSELL FRANKS.