

UNITED STATES PATENT OFFICE

2,423,665

ACID RESISTANT ALLOY

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No Drawing. Application October 5, 1944,
Serial No. 557,370

3 Claims. (Cl. 75—125)

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This invention relates to an acid resistant alloy and particularly to an alloy having the major constituents iron, nickel and chromium and the minor constituents copper, silicon, molybdenum, manganese, and carbon.

It has been assumed heretofore that cast austenitic types of nickel chrome and chrome nickel alloys of extreme ranges in composition are corrosion and oxidation resistant, but corrosion and oxidation resistant services have been alleged over such broad ranges of chemical composition that continuing difficulties in one form or another have resulted.

It is the object of this invention to prepare an alloy that is resistant to sulphuric acid in all concentrations, and which has excellent corrosion resistance to certain other acids; which has greatly improved inter-crystalline film cohesion properties, and which can be processed by foundry operations more normal to the manufacture of austenitic alloys. Other objects of the invention will appear hereinafter.

The objects of the invention are accomplished, generally speaking, by an alloy containing a mean of 28.5% nickel, a mean of 20.5% chromium, a mean of 2.5% copper, a mean of 2.5% silicon, a mean of 1.7% molybdenum, and not more than .1% carbon. The alloy should also contain a small amount of manganese, and may contain small amounts of the usual impurities. We have discovered a relationship and a balance between the major and minor constituents of the alloy that produces an inter-crystalline cohesion film which, at room and high temperatures, is greatly increased in strength, and that reduces manufacturing (foundry) hazards common to this complex type of austenitic alloy.

The components of the alloy bear a definite relation to each other, the percentage of iron being greater than the nickel, the percentage of nickel being greater than the chromium, the percentage of chromium being greater than the copper, and the percentage of silicon being greater than the molybdenum. Percentages of the various constituents can vary from the mean either by increase or by reduction in accordance with the principles set forth hereinafter, and in practice will do so, because the actual constitution of an alloy is affected to some extent by practical metallurgical controls, but the mean analysis is always the objective.

In this specification the composition of the alloys will be given primarily as a mean of good practice, secondarily by reference to those per-

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missible variations from the mean that constitute a preferred range, and sometimes by setting forth the results of variations beyond the preferred ranges. The alloys of this invention in which each ingredient is present in a percentage about its mean of good practice, are excellent.

Iron is present in greater amount than any other metal, but not more than 50%. Its percentage varies according to the amount of other ingredients employed, being less where a maximum of other elements is present, and more where a minimum of the other elements is present. Permissible variations in iron content are therefore greater than in the case of any other element.

Nickel is present in a greater amount than any element except iron. Its mean is at 28.5% and it may be increased to 30% or decreased to 27% while maintaining the fundamental characteristics of the alloy.

Chromium is present in an amount less than iron or nickel but greater than all other elements combined. Its mean is at 20.5%, and it may be increased to 22% or decreased to 19% while maintaining the fundamental characteristics of the alloy.

Among the minor constituents of the alloy, copper is usually but not always present in the greatest amount, but the copper content is small compared to the content of iron, nickel or chromium. Its mean is about 2.5%, and it can be increased to about 2.92% or decreased to 2.17% while maintaining the essential characteristics of the alloy. Although increases in copper to 3.5% and even to 5.5% or more have been attempted on some occasions and have resulted in the production of alloys having characteristics satisfactory in some respects, tests have shown that in the balanced alloy increasing copper beyond 3.0% is without gain.

Silicon is present in an amount preferably greater, and not less, than the percentage of molybdenum. Its mean of good practice is about 2.5% and its preferred extensions are upward to 3.0% and downward to 2.0%. The silicon content has also been tested upward to about 3.5% and downward to about 1.25%, but percentages nearer the mean are preferred.

Molybdenum is present in a mean of about 1.7% which may be increased to 1.95% or decreased to 1.45% with the production of sound alloys of superior characteristics. Reducing the molybdenum content somewhat below 1% greatly increases the rate of corrosion by sulphuric acid. Working in that region is therefore deemed to

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resolve in unsound practice, even though some of the alloys produced may be satisfactory for particular purposes. Satisfactory alloys have been produced with a molybdenum content of 1.95%, but a further increase seems to produce no compensating improvement in the properties of the alloy. More uniform and superior alloys are produced with the molybdenum content closer to the mean.

Carbon is always present but should be kept low in the alloy, with a maximum content of .1%.

A small amount of manganese should be present in the alloy. A mean of .75% manganese has been found to be beneficial. This has been increased to above 1.0% and even to 2.0% and decreased to 0.4%, but it is preferred to keep it close to the mean.

In making the alloy, the components are melted, for instance in an induction melting furnace, and cast into molds which after freezing are cleaned, annealed, and passivated. Annealing is carried out at a temperature and for a time dependent to some extent upon mass and carbon content. With very low carbon, quenching in water after holding for one-half hour at 1600° F. may be adequate; but for average alloys within the invention, water quenching after a half-hour at approximately 1950 to 2100° is preferred. After quenching, the casting is cleaned by such methods as sand-blasting and pickling, and is passivated in nitric acid of 20 to 40%, either warm or at room temperatures. Other acids may also be employed for passivating.

The alloys of the mean and of the preferred extensions thereof are highly resistant to sulphuric acid in all strengths. They have been proven by testing alloys of various compositions in 10%, 40%, 65%, 78% and 93% sulphuric acid at 80° C. These alloys are also capable of withstanding the Huey nitric acid corrosion test as described in the American Society for Testing Materials A262-43T.

The following examples illustrate the invention; they do not constitute a limitation.

Alloy	Examples			
	1	2	3	4
Ni.....	27.68	27.50	28.28	28.5
Cr.....	19.25	19.72	19.89	20.5
Cu.....	2.17	2.57	2.82	2.5
Si.....	2.00	2.50	3.02	2.5
Mo.....	1.80	1.45	1.60	1.7
C.....	.07	.07	.07	.07
Mn.....	.76	.70	.80	.75
Fe.....	To make substantially 100%.			

The new alloys, particularly those of the preferred ranges in composition, have greatly improved inter-crystalline film cohesion properties, and possess a marked freedom from the foundry difficulties previously experienced. These improvements constitute a very great advance in

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alloys of this complex type, and with their very high resistance to corrosion, permit their use in new fields.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that we do not limit ourselves to the specific embodiments thereof except as defined in the appended claims.

We claim:

1. A corrosion resistant alloy of improved crystalline and structural properties comprising

Ni about 27-30%
Cr about 19-22%
Cu about 2.0-3.0%
Si about 2.0-about 3.0%
Mo about 1.45-about 1.95%
C trace-0.1%
Mn about .5-2.0%

and the remainder Fe, the ratio of Si to Mo being greater than one.

2. A corrosion resistant alloy of improved crystalline and structural properties comprising

Ni about 28.5%
Cr about 20.5%
Cu about 2.5%
Si about 2.5%
Mo about 1.7%
C about .07%
Mn about .75%

and the remainder Fe.

3. A corrosion resistant alloy of improved crystalline and structural properties comprising

Ni about 27-30%
Cr about 19-22%
Cu about 1.25-3.5%
Si about .7-3.5%
Mo about .5-2.0%
C trace-0.1%
Mn about .5-1.0%

and the remainder Fe, the ratio of Si to Mo being greater than one.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,528,478	Hadfield	Mar. 3, 1925
2,241,369	Ziegler	Mar. 6, 1941
2,172,421	Uglic	Sept. 12, 1939
2,185,987	Parsons	Jan. 2, 1940
2,200,208	Parsons	May 7, 1940
2,225,440	Becket	Dec. 17, 1940
2,214,128	Fontana	Sept. 10, 1940