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NICKEL-BASE ALLOY

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4 Claims. (Cl. 75—171)

This invention relates to corrosion resistant alloys and refers more specifically to nickel base alloys containing essentially molybdenum or chromium or tungsten or mixtures of two or three of such metals, and which may contain iron as an incidental ingredient or diluent. This application is a division of application Serial No. 242,285, filed November 25, 1938.

Alloys of nickel and molybdenum have been disclosed in Patent 1,375,082, issued to A. W. Clement, and alloys of nickel, molybdenum and iron have been disclosed in Patent 1,710,445, issued to F. M. Becket My prior Patent 1,836,317, discloses similar alloys containing chromium in addition to the other elements. The resistance of each of those alloys to corrosion is very great, and they have been widely used in the fabrication of articles required to be resistant to corrosion. Although their resistance to hydrochloric acid is excellent, there is a demand for alloys having an even greater resistance to this acid, and it is a principal object of the present invention to provide such alloys.

The invention is based on my discovery that the corrosion resisting properties of nickel base alloys containing molybdenum or chromium or tungsten or mixtures of two or three of such metals, and incidental amounts of iron, are markedly improved by the addition of relatively small amounts of antimony. As little as 0.08% to 0.12% antimony effects a striking improvement, and although as much as 6% of this element may be used it is ordinarily neither necessary nor desirable that it exceed 0.5%.

The invention is an alloy comprising 10% to 45% metal selected from the group consisting of molybdenum, chromium, tungsten, and mixtures thereof; between 0.08% and 6% antimony; silicon in an amount not exceeding 2%; manganese in an amount not exceeding 3%; carbon in an amount less than 1%; and the remainder principally nickel, the nickel content being greater than 45%. A preferred range of antimony percentages is 0.2% to 0.5%. Vanadium may also be included, suitably in an amount less than 3%. Preferably, 10% to 25% molybdenum, 3% to 7% tungsten, and 10% to 20% chromium are present.

Iron may be added to the alloy as a diluent and for the purpose of making it more workable at the expense of an unimportant decrease in corrosion resistance. In such a case, it is necessary to strike a balance between an increase in the corrosion rate and an increase in workability, and for certain applications it is possible to use an alloy containing no iron or only a minor amount of iron, while for other applications it is desirable to use an alloy containing a substantial proportion, say 2% to 10%, of iron. However, iron should not be present in an amount exceeding 25%.

The following table shows compositions of typical alloys within the invention and results of corrosion tests of such alloys, compared with the results of tests of alloys, otherwise similar, containing no antimony.

Composition

(Remainder nickel and 0.3% vanadium)

Alloy No.	Per-cent C	Per-cent Fe	Per-cent Mn	Per-cent Si	Per-cent Mo	Per-cent W	Per-cent Cr	Per-cent Sb
1	0.07	20.3	0.5	0.3	19.6	None	None	None
2	0.06	21.3	0.5	0.3	18.8	None	None	0.06
3	0.06	21.3	0.5	0.3	18.3	None	None	0.12
4	0.06	20.7	0.5	0.4	19.6	None	None	0.25
5	0.06	21.3	2.1	0.3	19.8	None	None	0.49
6	0.04	21.2	0.5	0.3	19.3	None	None	1.57
7	0.05	21.4	2.1	0.3	20.7	None	None	3.32
8	0.08	20.9	0.5	0.3	20	None	None	7.18
9	0.09	5	0.5	0.6	16.8	5	15.7	None
10	0.06	6.7	0.5	0.3	17	4.7	13.9	0.05
11	0.07	7	0.5	0.3	17.2	4.2	14.2	0.1
12	0.07	7.5	0.5	0.3	16.6	4.6	14.0	0.25
13	0.08	5	0.6	0.3	18	4.7	13.8	0.44
14	0.1	5	0.5	0.7	17.5	5	14.9	1.67
15	0.06	5	0.6	0.3	17.9	4.7	14.5	2.73
16	0.12	5	0.5	0.8	18.3	4.7	15	5.9

Corrosion rate in milligrams per square centimeter per hour in boiling concentrated aqueous HCl

Alloy No.	Non-aerated HCl			HCl aerated by passing stream of air through solution		
	First period 45 hrs.	Next period 45 hrs.	Next period 52 hrs.	First period 45 hrs.	Next period 45 hrs.	Next period 65 hrs.
1	0.6	0.8	0.9	0.8	0.9	1.0
2	0.6	0.8	*	*	*	*
3	1.1	0.9	*	*	*	*
4	0.2	0.2	*	*	*	*
5	0.3	0.3	0.3	0.4	0.4	0.6
6	0.2	0.1	*	0.5	0.4	0.4
7	0.1	0.1	0.2	0.3	0.3	0.3
8	0.7	1.0	*	1.6	1.6	1.6
9	4.0	7.0	7.0	4.0	7.0	*
10	2.2	4.9	*	*	*	*
11	1.4	3.2	*	*	*	*
12	0.4	0.5	*	*	*	*
13	0.3	0.3	0.4	0.5	0.6	*
14	0.3	0.3	*	0.3	0.7	*
15	0.3	0.5	0.7	0.4	0.8	*
16	2.2	3.3	*	2.2	4.3	*

* Not tested.

The valuable increase in resistance to attack by hydrochloric acid imparted by antimony is

apparent from the above examples. While certain specific compositions have been described herein by way of example, the invention is not limited to or by such examples. Thus, it is possible to substitute cobalt for at least a part of the nickel content without materially affecting the properties of the alloy and without departing from the invention.

I claim:

1. Nickel base alloy comprising at least one metal of the group consisting of chromium, molybdenum, and tungsten, the proportion of such metal or metals being between 10% and 45%; antimony in a proportion, between 0.08% and 6%, sufficient to increase the resistance of the alloy to corrosion by hydrochloric acid; iron in an effective proportion not exceeding 25%; the remainder substantially all nickel; the nickel content being greater than 45%.

2. Nickel base alloy comprising 10% to 40% molybdenum; 0.2% to 0.5% antimony; a substantial proportion less than 25% of iron; the remainder substantially all nickel, the nickel content being greater than 45%.

3. Nickel base alloy comprising 10% to 25% molybdenum; 0.2% to 0.5% antimony; 10% to 25% iron; the remainder substantially all nickel, the nickel content being greater than 45%.

4. Nickel base alloy comprising 10% to 30% molybdenum; 3% to 7% tungsten; 10% to 25% chromium; 0.2% to 0.5% antimony; iron in a minor but substantial proportion less than 10%; the remainder substantially all nickel, the nickel content being greater than 45%, and the proportion of the metals molybdenum, tungsten, and chromium not exceeding 45%.

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