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Murakami et al.

[11] **3,833,359**

[45] **Sept. 3, 1974**

[54] **HIGH CR LOW NI STAINLESS STEEL**

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[52] **U.S. Cl.** .... **75/125,** 75/128 W, 75/128 G

[51] **Int. Cl.** **C22c 39/54,** C22c 39/20

[58] **Field of Search**............. 75/125, 128 W, 128 G

[56] **References Cited**

UNITED STATES PATENTS

3,285,738	11/1966	Johnson	75/125
3,362,813	1/1968	Ziolkowski	75/125
3,740,213	6/1973	Hellner	75/128 W

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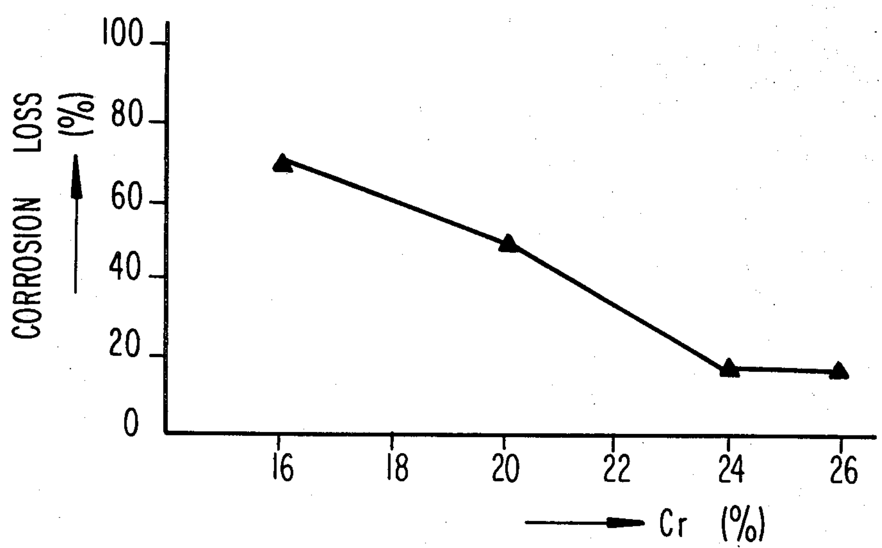
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A high Cr low Ni stainless steel comprising not more than 0.10% C, not more than 2.0% Si, not more than 2.0% Mn, the sum of P and S being not more than 0.04%, 24 to 30% Cr, 2.0 to 3.0% Ni, 0.5 to 1.0% Mo, 0.03 to 0.10% Nb, 0.4 to 1.0% Cu and the remainder Fe and incidental impurities. This stainless steel predominantly exhibits the ferrite matrix and is quite resistant to the intergranular corrosion and the stress corrosion cracking.

2 Claims, 7 Drawing Figures



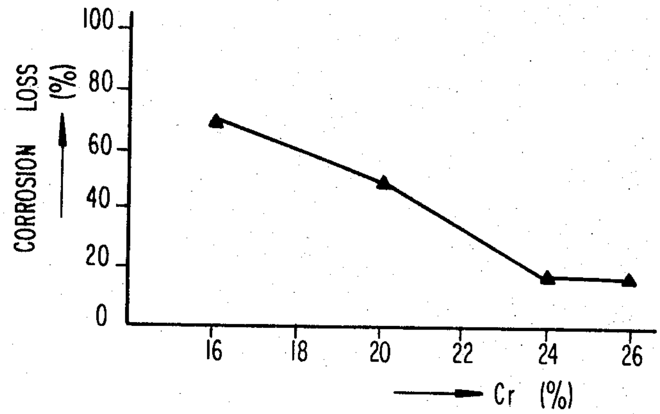


FIG.1

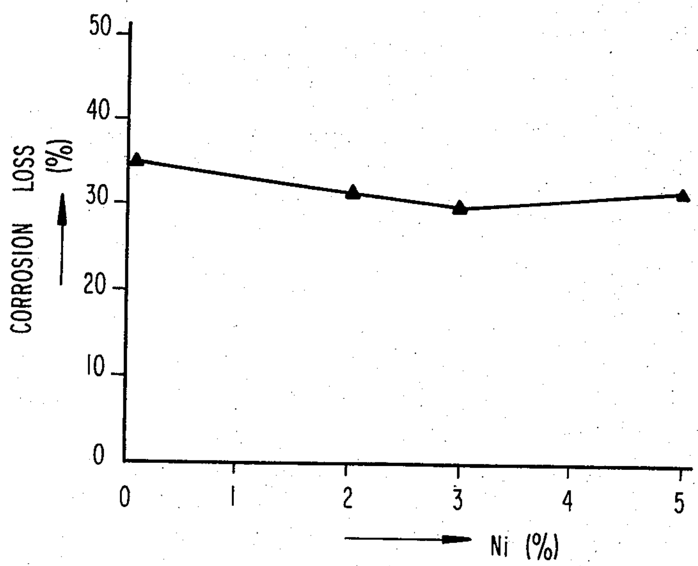


FIG.2

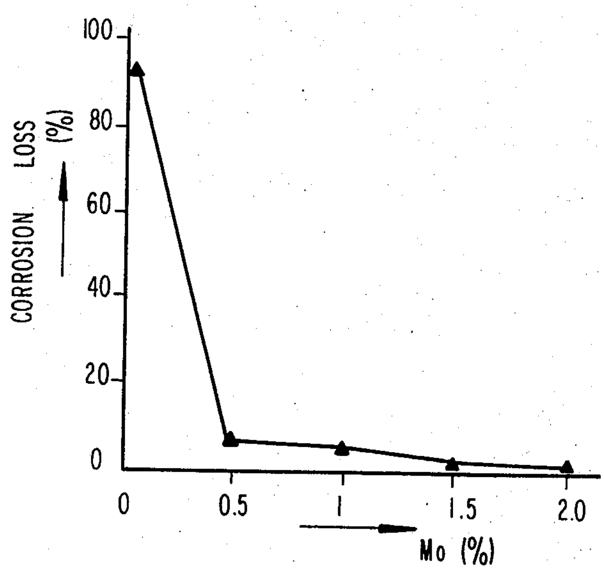


FIG.3

FIG. 4

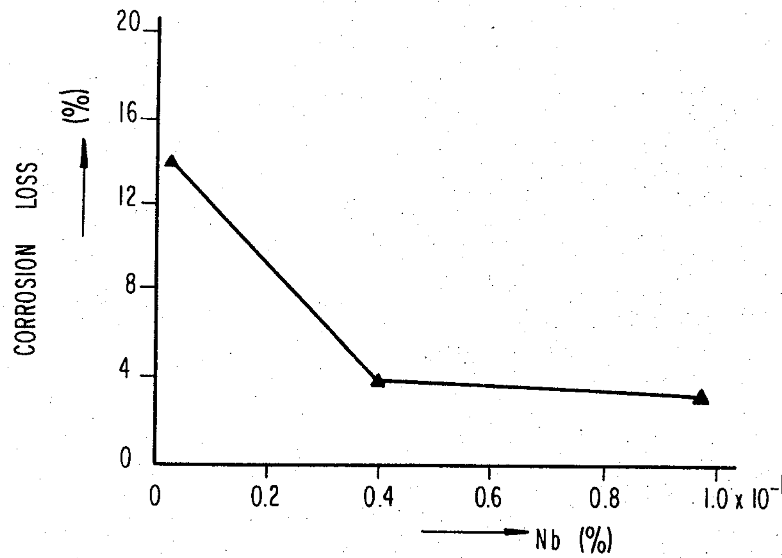


FIG. 5

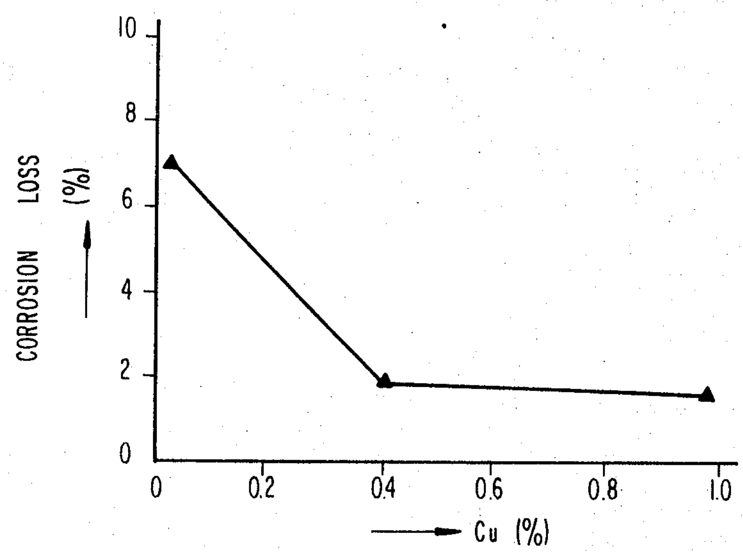


FIG. 6

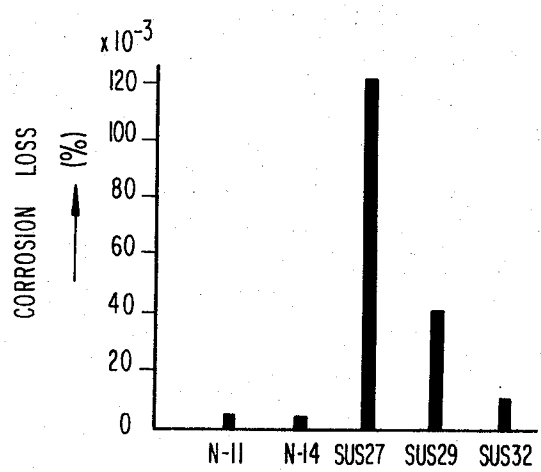


FIG. 7

HIGH CR LOW NI STAINLESS STEEL

BACKGROUND OF THE INVENTION

1. Filed of the Invention

This invention relates to a stainless steel, and more particularly to a high Cr low Ni stainless steel having a structure composed of major part of ferrite and minor part of austenite and being quite resistant to acidic attack.

2. Description of the Prior Art

The known austenitic matrix stainless steel, a typical one of which is the 18Cr-8Ni steel, exhibits a high resistance to acidic attack and is used in various corrosive environments but has the defects of intergranular corrosion and stress corrosion cracking.

On the other hand, the known ferritic matrix stainless steel, typical ones of which are 18 Cr steel and 25 Cr steel, exhibits inferior corrosion resistance as compared with the austenitic matrix stainless steel and is used under the restricted corrosive environments, but has the distinctive feature that intergranular corrosion and stress corrosion cracking occur only to a slight extent.

SUMMARY OF THE INVENTION

This invention provides a novel stainless steel exhibiting both high strength comparable with that of the known austenitic matrix stainless steel and excellent corrosion resistance without intergranular corrosion and stress corrosion cracking, which are comparable with that of the known austenitic matrix stainless steel. After many studies on compositions and properties of the austenitic matrix stainless steel, we, the inventors, have discovered that above described stainless steel having both high strength and favorable corrosion resistance can be obtained by adding a definite amount of Ni, Mo and Cu to the high Cr stainless steel. The resulting stainless steel comprises not more than 0.10% C, not more than 2.0% Si, not more than 2.0% Mn, sum of P and S being not more than 0.04%, 24 to 30% Cr, 2.0 to 3.0% Ni, 0.5 to 1.0% Mo, 0.03 to 0.10% Nb, 0.4 to 1.0% Cu and the remainder Fe except for the incidental impurities, and the matrix of the steel is composed of the major part of ferrite and minor part of austenite caused by the addition of Ni. All percents given herein are by weight.

It will be apparent from Examples hereinafter described that this stainless steel exhibits far superior resistance to the attack of acids in comparison with that of the conventional austenitic stainless steel.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

FIG. 1 is a graph showing the relation between corrosion loss and the Cr content of the stainless steel according to this invention dipped in a boiling 5% H_2SO_4 aqueous solution for 6 hours,

FIG. 2 is a graph showing the relation between the corrosion loss and the Ni content of the stainless steel dipped in a boiling 5% H_2SO_4 aqueous solution for 6 hours,

FIG. 3 is a graph showing the relation between the corrosion loss and the Mo content of the stainless steel dipped in a boiling 5% H_2SO_4 aqueous solution for 6 hours,

FIG. 4 is a graph showing the relation between the corrosion loss and the Nb content of the stainless steel dipped in a boiling 5% H_2SO_4 aqueous solution for 6 hours,

FIG. 5 is a graph showing the relation between the corrosion loss and the Cu content of the stainless steel dipped in a boiling 5% H_2SO_4 aqueous solution for 6 hours,

FIG. 6 is a graph showing the corrosion loss of the stainless steels according to this invention and that of known stainless steels, all dipped in a boiling 5% H_2SO_4 aqueous solution for 6 hours, and

FIG. 7 shows a photograph of a microscopic structure (degree of magnification 80) of the stainless steel according to this invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The preferred ranges of the contents of the alloying elements are determined by the following reasons.

The amount of C, Si and Mn of this stainless steel is that of the usual ferritic stainless steel.

Less than 24% Cr is not effective to exhibit fully the corrosion resistance of the resulting steel, as shown in FIG. 1, while more than 30% Cr makes the production of the steel difficult. A Ni content less than 2% or more than 3% reduces the corrosion resistance of the resulting steel, as shown in FIG. 2.

Mo serves to strengthen the passive state of the Fe-Cr-Ni steel. Less than 0.5% Mo exhibits poor resistance to the attack of H_2SO_4 as shown in FIG. 3, while more than 1.0% Mo is uneconomical and reduces the impact resistance of the resulting steel.

Nb is known as an element which improves the resistance of the stainless steel to the attack of H_2SO_4. Less than 0.03% Nb is not effective to improve the resistance to H_2SO_4 attack, as shown in FIG. 4, whereas more than 0.10% Nb is uneconomical and does not increase the corrosion resistance further.

Cu serves effectively to improve the acid resistance. Less than 0.4% Cu is not effective, whereas more than 1.0% Cu reduces the toughness of the steel.

The composition of the high Cr low Ni stainless steel of this invention is as follows.

	% by weight
Carbon	0.03 – 0.10
Silicon	0.5 – 2.0
Manganese	0.5 – 2.0
Phosphorous plus Sulfur (P not more than 0.04; S not more than 0.04)	0 – 0.04
Chromium	24 – 30
Nickel	2 – 3
Molybdenum	0.5 – 1.0
Niobium	0.03 – 0.10
Copper	0.4 – 1.0
Iron	Balance

The stainless steels of this invention can be prepared using conventional processes for the production of stainless steels, for example, by centrifugal casting.

Some examples of this invention prepared by the centrifugal casting method will be described with reference to the drawings (FIG. 6) and Tables (1 and 2).

Table 1

Chemical Compositions of Stainless Steel Samples (wt%)

Sample	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb	Ti
*N-11	0.08	0.96	0.86	0.028	0.013	25.08	3.01	0.5	0.50	0.03	
*N-12	0.09	0.89	1.16	0.025	0.012	24.20	3.01	0.86	0.84	0.04	
*N-13	0.09	0.99	1.06	0.025	0.012	25.62	2.45	0.92	0.99	0.04	
*N-14	0.08	1.00	1.12	0.026	0.013	28.70	3.00	0.80	0.71	0.04	
*N-15	0.08	0.98	1.01	0.020	0.018	26.38	2.55	0.72	0.68	0.03	
**SUS-27	<0.08	<1.00	<2.00			18.00 ~ 20.00	8.00 ~ 11.00				
**SUS-29	<0.08	<1.00	<2.00				9.00 ~ 13.00			>5×C	
**SUS-32	<0.08	<1.00	<2.00			16.00 ~ 18.00	10.00 ~ 14.00	2.00 ~ 3.00			

* samples of the stainless steel according to this invention
** comparative samples of a known stainless steel

Table 2

Mechanical Properties of the Stainless Steel Samples Listed in Table 1

Sample	Tensile Strength (Kg/mm^2)	Yield Point (Kg/mm^2)	Elong. (%)	Reduction in Area (%)	Corrosion in Boiling 5% H_2SO_4 Aq. Solution: Corrosion Loss ($g/m^2hr.$)	Corrosion Loss (%)
*N-11	69.6	46.7	25.6	53.2	2.0	4.09×10^{-3}
*N-12	69.0	45.8	26.2	50.2	1.8	
*N-13	71.5	49.3	25.0	49.8	1.5	
*N-14	70.1	49.0	25.5	48.9	1.6	3.82×10^{-3}
*N-15	69.4	47.6	26.4	50.5	1.6	
**SUS-27	49.8	25.1	46.0	60.2		178×10^{-3}
**SUS-29	>52		>45	>50		44.1×10^{-3}
**SUS-32	>52		>45	>60		9.62×10^{-3}

The data on the corrosion loss shown in the Table **2** are presented graphically in FIG. **6.**

The test sample N-**12** is etched electrolytically in a 10% chromate solution, and the microscopic structure (degree of magnification 80) of the etched sample is shown in FIG. **7.** It will be recognized from FIG. **7** that the stainless steel of this invention is composed of a ferrite matrix with a minor amount of austenite phase dispersed therein.

The following are clear from the Tables and FIG. **6**: The stainless steel according to this invention exhibits better acid resistance, such as resistance to the attack of sulfuric acid, than the conventional austenitic stainless steels; the corrosion resistance of the steel of this invention is twice that of the conventional austenitic stainless steel SUS-32 to which Mo was added to improve the sulfuric acid resistance.

The elongation and the reduction in area of the steel of this invention are slightly inferior to that of the conventional austenitic matrix stainless steel, but the tensile strength and the yield point of the steel of this invention is superior to that of the conventional austenitic matrix stainless steel.

In addition, since the matrix of the steel of this invention is ferritic, the intergranular corrosion and the stress corrosion cracking results to only a slight extent with the steel.

Accordingly, the stainless steel of this invention has the distinctive features of both the austenitic and ferritic matrix stainless steels, and can be widely used in the chemical industry, the paper making industries, and the other industrial applications requiring steels having high strength and corrosion resistance, especially resistance to the stress corrosion cracking.

While this invention has been described with reference to particular embodiments thereof, it will be understood that the numerous modifications may be made by those skilled in the art without actually departing from the scope of the invention.

Therefore, the appended claim is intended to cover all such equivalent variations as coming within the true spirit and scope of the invention.

What is claimed is:

1. A high chromium low nickel stainless steel comprising not more than 0.10% C, not more than 2.0% Si, not more than 2.0% Mn, the sum of P and S being not more than 0.04%, 24 to 30% Cr, 2.0 to 3.0% Ni, 0.5 to 1.0% Mo, 0.03 to 0.10% Nb, 0.4 to 1.0% Cu and the remainder Fe, all of said percents being by weight.

2. The high chromium low nickel stainless steel of claim **1,** wherein said steel comprises the following, said percentages being by weight:

Carbon	0.03 – 0.10%
Silicon	0.5 – 2.0%
Manganese	0.5 – 2.0%
Phosphorus plus Sulfur	0 – 0.04%
Chromium	24 – 30%
Nickel	2 – 3%
Molybdenum	0.5 – 1.0%
Niobium	0.03 – 0.10%
Copper	0.4 – 1.0%
Iron	Balance.

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