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3,015,559

OXIDATION RESISTANT CHROMIUM ALLOY

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No Drawing. Filed Sept. 25, 1959, Ser. No. 842,522

4 Claims. (Cl. 75-176)

This invention relates to high temperature, oxidation resistant alloys and, more particularly, to binary alloys of chromium and rare earth elements.

The field of high temperature metallurgy is limited generally to the utilization of oxidation resistant iron and nickel base alloys for applications in air, and the use of even these materials is limited to temperatures not in excess of 2000° F. The only other available materials which might be expected to have useful strength and oxidation resistance above 2000° F. are chromium base alloys. While high temperature, high strength, structural chromium base alloys do exist, the usefulness of such alloys has been limited by oxide film formation on the surface of such alloys, which does not afford sufficient protection against further oxidation at high temperatures. The oxide film which is formed during heating of the metal in air provides some useful protection at temperatures up to 1700° F. Above this temperature, oxidation is sufficiently rapid to discourage use of the metal at such elevated temperatures. The oxidation resistance of chromium at 2000° F. cannot be compared favorably to that of iron or nickel base alloys containing minor additions of chromium or aluminum.

Chromium base alloys react with the nitrogen in air even at temperatures below 1700° F. to create a further problem. Iron and nickel base alloys are not effected in this manner. The nitrogen contamination is not limited to a surface attack on the alloy, but it extends deeply into the chromium because of a rather rapid penetration of nitrogen into the metal by diffusion. The nitrogen penetration converts the chromium alloy from a ductile, high strength, structural metal to a brittle substance. Elements such as beryllium, boron, aluminum, titanium, zirconium and silicon which tend to improve the oxidation resistance of iron or nickel base alloys are ineffective for improving the high temperature stability of chromium.

In copending application, Serial No. 710,367, filed January 21, 1958, now U.S. Patent 2,955,937, in the names of James A. McGurty, John F. Collins and Vincent P. Calkins for "Oxidation Resistant Chromium Alloy," binary alloys are disclosed and claimed which consist of from about 0.2 weight percent to about 2.5 weight percent yttrium with the balance being chromium. Chromium base alloys with small amounts of yttrium are stable in air to temperatures in excess of 2000° F.

The problem existed to develop alloys which would provide high strength, good oxidation resistance, and cladding protection for base alloys at temperatures in excess of 2000° F. It was also necessary to provide alloys which were not contaminated by nitrogen.

The invention of the present application provides oxidation resistant chromium-rare earth element alloys which are useful in air at temperatures in excess of 2000° F.

It is an object of our invention to provide an oxidation resistant alloy of chromium and a rare earth element selected from the group consisting of cerium, praseodymium, neodymium, samarium, gadolinium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium.

It is another object of our invention to provide an alloy which has superior oxidation resistance at temperatures in excess of 2000° F.

It is a further object of our invention to provide a cladding alloy which is not contaminated by nitrogen.

In carrying out our invention in one form, from 0.5 to

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6 weight percent of a rare earth element is combined with chromium to provide a high temperature, oxidation resistant alloy.

These and various other objects, features and advantages of the invention will be better understood from the following description.

We discovered unexpectedly that small additions of various rare earth elements to chromium produced alloys which had superior oxidation resistance in air at temperatures in excess of 2000° F. Furthermore, such alloys were not contaminated by nitrogen. The addition of from 0.5 to 6.0 weight percent of these rare earth elements to chromium provided these extraordinary effects.

During the research which led to the discovery of these oxidation resistant chromium alloys, a series of small, vacuum melted, chromium-rare earth element buttons were prepared. These alloy buttons, containing from 0.5 to 6.0 weight percent rare earth element and the balance being chromium, were heated in air at 2300° F. for 100 hours. The specimens were then examined metallographically and weight changes measured. The data tabulated in Table I showed excellent oxidation resistance of the chromium base alloys containing rare earth elements as compared to chromium.

TABLE I

Oxidation resistance of chromium base alloys

[100 hours, air, 2300° F.]

Additions	Weight Gain, Percent	N ₂ Absorption, p.p.m.
100% Cr.....	5.6	16,500
Cr-2 Ce.....	.38	
Cr-0.5 Pr.....	.20	650
Cr-1 Pr.....	.30	
Cr-2 Pr.....	.17	30
Cr-0.5 Nd.....	.25	1,170
Cr-2 Nd.....	.20	280
Cr-1 Sm.....	.49	1,170
Cr-2 Sm.....		1,040
Cr-5 Sm.....	.55	1,112
Cr-0.5 Gd.....	.23	430
Cr-2 Gd.....	.17	230
Cr-0.5 Dy.....	.95	1,090
Cr-1 Dy.....	.92	
Cr-2 Dy.....	.32	1,170
Cr-4 Dy.....	.24	
Cr-6 Dy.....	.32	1,480
Cr-1 Ho.....	.28	580
Cr-2 Ho.....	.15	150
Cr-0.5 Er.....	.46	1,250
Cr-2 Er.....	.22	300
Cr-5 Er.....	.14	60
Cr-1 Tm.....	.72	850
Cr-2 Tm.....	.42	1,990
Cr-2 Yb.....	.64	900
Cr-1 Lu.....	.22	

While other modifications of this invention which may be employed within the scope of the invention have not been described, the invention is intended to include all such as may be embraced within the following claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A binary alloy of chromium which consists of chromium and 0.5 to 6.0 weight percent of a rare earth element selected from the group consisting of cerium, praseodymium, neodymium, samarium, gadolinium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium.

2. A binary alloy of chromium and praseodymium containing from 0.5 to 2.0 weight percent of praseodymium.

3. A binary alloy of chromium and gadolinium containing from 0.5 to 2.0 weight percent of gadolinium.

4. A binary alloy of chromium and erbium containing from 0.5 to 5.0 weight percent of erbium.

References Cited in the file of this patent

Hampel: Rare Metals Handbook, 1954, page 344, published by Reinhold Publishing Corp., New York, N.Y.