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3,017,265 OXIDATION RESISTANT IRON-CHROMIUM ALLOY

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6 Claims. (Cl. 75-126)

This invention relates to high temperature, oxidation resistant alloys and, more particularly, to ternary alloys of iron, chromium and yttrium.

For applications in air, the field of high temperature metallurgy is, for most practical purposes, limited to the utilization of oxidation resistant iron base and nickel base alloys, and the use of even these materials is limited to temperatures not in excess of 2000° F. The only other generally available materials which might be expected to have useful strength, oxidation resistance above 2000° F. and workability are chromium base or iron-chromium base alloys. While high temperature, high strength, structural, chromium base and iron-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 chromium oxide film which is formed during heating of the metal in air provides some useful protection at temperatures up to 2000° F. Above this temperature, oxidation is sufficiently rapid to discourage use of the metal at such elevated temperatures.

In copending application, Serial No. 710,367, filed January 21, 1958, now Patent No. 2,955,937, granted October 11, 1960, in the names of James A. McGurty, John F. Collins and Vincent P. Calkins, a binary oxidation resistant chromium alloy is disclosed and claimed which consists of from about 0.2 weight percent to about 2.5 weight percent yttrium and the balance being chromium. Chromium base alloys with small amounts of yttrium are stable in air to temperatures well above 2000° F. These binary alloys of chromium and yttrium have excellent ductility and structural applications.

The problem existed to develop iron-chromium base alloys which would provide high strength, good oxidation resistant, and cladding protection for base alloys at temperatures in excess of 2000° F. The invention of the present application provides such improved iron-chromium base alloys.

It is an object of our invention to provide an oxidation resistant alloy of iron, chromium and yttrium.

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 another object of our invention to provide an iron-chromium base alloy with increased workability.

It is a further object of our invention to provide an iron-chromium base alloy with oxidation resistance at elevated temperatures which does not affect adversely the workability of the alloy.

In carrying out our invention in one form, from 0.5 to 5.0 weight percent yttrium is combined with an iron-chromium base alloy having from 20.0 to 95.0 weight percent chromium and the balance of iron 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 yttrium to iron-chromium base alloys produced alloys which had superior oxidation resistance in air at temperatures in excess of 2000° F. The addition of from 0.5 to 5.0 weight percent of yttrium to iron-chromium alloys

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having from 20.0 to 95.0 weight percent chromium and the balance of iron provided these extraordinary effects. While the above weight percent of yttrium improved oxidation resistance of this ternary alloy, from 0.5 to 3.0 weight percent yttrium appeared to be the optimum amount of this addition to iron-chromium base alloys. From 20.0 to 50.0 and from 70.0 to 95.0 weight percent chromium appeared to provide the optimum oxidation resistant iron-chromium yttrium alloys.

During the research which led to the discovery of these oxidation resistant iron-chromium alloys, a series of small vacuum melted iron-chromium-yttrium buttons were prepared. These alloy buttons, containing from .05 to 5.0 weight percent yttrium, from 20.0 to 95.0 weight percent chromium and the balance of iron 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 the excellent stability of the iron-chromium base alloys containing yttrium as compared to iron-chromium base alloys.

TABLE I
Oxidation resistance iron-chromium alloys
[100 hours, air, 2300° F.]

Additions	Weight Gain, Percent
Fe-25 Cr-----	29.1
Fe-35 Cr-----	2.5
Fe-25 Cr-1.5 Y-----	0.06
Fe-30 Cr-1.0 Y-----	0.05
Fe-35 Cr-0.5 Y-----	0.58
Fe-35 Cr-1.0 Y-----	0.05
Fe-35 Cr-1.5 Y-----	0.61
Fe-35 Cr-2.0 Y-----	0.54
Fe-35 Cr-3.0 Y-----	0.56
Fe-35 Cr-5.0 Y-----	0.72
Fe-40 Cr-1.0 Y-----	0.30
Fe-48.5 Cr-1.5 Y-----	0.40
Fe-63.5 Cr-1.5 Y-----	1.20
Fe-73.5 Cr-1.5 Y-----	0.33
Fe-78.5 Cr-1.5 Y-----	0.42
Fe-83.5 Cr-1.5 Y-----	0.37
Fe-88.5 Cr-1.5 Y-----	0.19
Fe-93.5 Cr-1.5 Y-----	0.36

We discovered that less than 5 weight percent iron in the iron-chromium-yttrium alloy was not significant. Furthermore, the addition of less than 20 weight percent of chromium affected adversely the oxidation resistance of this ternary alloy.

Additionally, a number of 600 to 1,000 pound vacuum melts have been made to produce iron-chromium-yttrium ingots of approximately 250 pounds each. Each of these ingots consisted of from 0.8 to 1.15 weight percent yttrium, from 28.5 to 31.5 weight percent chromium, and the balance being iron. These ingots were reduced subsequently to sheet which was used as cladding on base alloys subjected to temperatures in the range of 2100° F. to 2300° F. These alloy claddings provided good oxidation resistance and high temperature protection for the base alloys.

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 ternary alloy of iron, chromium and yttrium which consists of from 0.5 to 5.0 weight percent yttrium, from 20.0 to 95.0 weight percent chromium, and the balance being iron.

2. A ternary alloy of iron, chromium and yttrium which consists of from 0.5 to 3.0 weight percent yttrium, from 20.0 to 95.0 weight percent chromium, and the balance being iron.

3. A ternary alloy of iron, chromium and yttrium which

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consists of from 0.5 to 5.0 weight percent yttrium, from 20.0 to 50.0 weight percent chromium, and the balance being iron.

4. A ternary alloy of iron, chromium and yttrium which consists of from 0.5 to 5.0 weight percent yttrium, from 70.0 to 95.0 weight percent chromium, and the balance being iron.

5. A ternary alloy of iron, chromium and yttrium which consists of from 0.8 to 1.15 weight percent yttrium, from 28.5 to 31.5 weight percent chromium, and the balance being iron.

6. A ternary alloy of iron, chromium and yttrium which

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consists of from 1. to 1.5 weight percent yttrium, from 25 to 35 weight percent chromium, and the balance being iron.

References Cited in the file of this patent

UNITED STATES PATENTS

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