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3,027,252
OXIDATION RESISTANT IRON-CHROMIUM
ALLOY

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ilton, Ohio, assignors to General Electric Company, a
corporation of New York
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3 Claims. (Cl. 75—126)

This invention relates to high temperature, oxidation
resistant alloys and, more particularly, to alloys of iron,
chromium, aluminum 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 ex-
pected 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. 842,517, filed
September 26, 1959, in the names of James A. McGurty
and John F. Collins, a ternary oxidation resistant iron-
chromium alloy is disclosed and claimed 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. Iron-chromium base alloys with small amounts of
yttrium are stable in air to temperatures well above 2000°
F. These ternary alloys of iron, chromium and yttrium
have good oxidation resistance at temperatures in excess
of 2000° F.

Iron-chromium base alloys which would provide high
strength, good oxidation resistance and cladding protec-
tion for base alloys at temperatures in excess of 2000° F.
are desirable. The invention of the present application
provides such iron-chromium base alloys with improved
workability and an improved oxide film.

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

It is another object of our invention to provide an
iron-chromium base alloy with an improved oxide film.

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

It is a further object of our invention to provide an
alloy which has superior oxidation resistance at tem-
peratures in excess of 2000° F.

In carrying out my invention in one form, from 0.5
to 4.0 weight percent aluminum, and from 0.5 to 3.0
weight percent yttrium are combined with an iron-chrom-
ium base alloy having from 20.0 to 95.0 weight percent
chromium and the balance of iron to provide a high tem-
perature, oxidation resistant alloy with improved work-
ability and an improved oxide film.

These and various other objects, features and advan-

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tages of the invention will be better understood from the
following description.

We discovered unexpectedly that small additions of
aluminum and yttrium to iron-chromium base alloys pro-
duced alloys which had superior oxidation resistance in
air at temperatures in excess of 2000° F., improved work-
ability, and improved oxide films. The addition of from
0.5 to 4.0 weight percent of aluminum, and from 0.5 to
3.0 weight percent yttrium to iron-chromium alloys hav-
ing from 20.0 to 95.0 weight percent chromium and the
balance of iron provided these extraordinary effects. While
this weight percent of aluminum improved this alloy,
3.0 weight percent aluminum appeared to be the opti-
mum amount of this addition to the alloy. Such an alloy,
containing 3.0 weight percent aluminum, provided an
enamel, thermal shock resistant, non-spalling film to
temperatures slightly below the melting point of 2600°
F. to 2700° F.

During the research which led to the discovery of these
oxidation resistant iron-chromium alloys, a series of small
vacuum melted iron-chromium-aluminum-yttrium buttons
were prepared. These alloy buttons, containing from 0.5
to 4.0 weight percent aluminum, from 0.5 to 3.0 weight
percent yttrium, from 20.0 to 95.0 weight percent chrom-
ium 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 shows the excellent stability of
the iron-chromium base alloys containing aluminum and
yttrium as compared with iron-chromium base alloys.
Table II shows the improved workability of

Fe—20.0—95.0Cr—0.5—4.0Al—0.5—3.0Y

as compared with Fe—25Cr—5Al—1Y.

TABLE I
Oxidation Resistant Iron-Chromium Alloys
[100 hours, air, 2300° F.]

Additions	Weight Gain, percent
Fe—25Cr—	29.10
Fe—35Cr—	2.50
Fe—25Cr—0.5Al—1Y—	0.30
Fe—25Cr—1.5Al—1Y—	0.30
Fe—25Cr—2.0Al—1Y—	0.20
Fe—25Cr—3.0Al—1Y—	0.18
Fe—25Cr—4.0Al—1Y—	0.30

TABLE II
Workability of Iron-Chromium Alloys

Additions	Workability
Fe—25Cr—5Al—1Y—	Hot rolling—splits, hot short.
Fe—25Cr—0.5Al—1Y—	Cold rolling—cracks.
Fe—25Cr—1.5Al—1Y—	Cold rolls readily.
Fe—25Cr—2.0Al—1Y—	Do.
Fe—25Cr—3.0Al—Y—	Do.
Fe—25Cr—4.0Al—1Y—	Cold rolls after annealing.

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.

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

1. An alloy of iron, chromium, aluminum and yttrium which consists of from 0.5 to 4.0 weight percent aluminum, from 0.5 to 3.0 weight percent yttrium, from 20.0 to 95.0 weight percent chromium, and the balance being iron.

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

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3. An alloy of iron, chromium, aluminum and yttrium which consists of 3.0 weight percent aluminum, 1.0 weight percent yttrium, 25.0 weight percent chromium, and the balance being iron.

References Cited in the file of this patent

UNITED STATES PATENTS

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2,813,789	Glaser	Nov. 19, 1957