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AUSTENITIC STEELS

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The present invention comprises new alloy steels of the austenitic type. This is a continuation-in-part of Serial No. 32,725, filed June 12, 1948.

It is the object of our invention to provide improved high temperature strength steels.

Our invention, in general, comprises austenitic alloy steels containing critical ranges of titanium or columbium (or a combination thereof) in combination with an associated critical content of boron and possessing a crystal structure resulting from heat treatment carried out above 1900° F. and up to about 2300° F. followed by quenching and tempering under conditions varying with desired specific properties.

In a more specific aspect, austenitic alloys embodying our invention are chrome-nickel steels, which are substantially devoid of tungsten and molybdenum, the high temperature physical properties of and in which have been improved by the presence of about 0.4 to 1% of a carbide forming addition agent such as tantalum, zirconium, titanium or columbium, preferably titanium or columbium, and an associated modifying element consisting of a smaller percentage of boron. The chrome-nickel steels contemplated are the usual austenitic chrome-nickel steels containing from about 17% to 19% chromium and about 11% to 12% nickel. The modifying element should be present in the range of about 0.01 to 0.03%, although some beneficial results can be obtained with a somewhat higher boron content up to about 0.10%. A small amount of carbon also may be present. In order to insure satisfactory hot-working quality, steels embodying our invention must contain at least four times as much titanium (or other carbide former) as carbon. Preferably, the carbon content should be low and preferably within the range of 0.03 to 0.10%. A ratio of 4 to 15 of the carbide former, such as the titanium or columbium, or both, compared to carbon, has been found satisfactory both for hot workability and strength at high temperatures.

Incidental minor alloying elements as, for example, manganese, silicon, sulfur and phosphorus, may be present either as useful additions for imparting special properties, or as incidental impurities. Manganese, for example, in the proportion of 0.2 to 2.0% may be added to restrain the transformation of austenite. Silicon may be merely an incidental impurity in the range of 0.1% to 1%, or may be increased to improve the resistance to certain types of corrosion. Sulfur and phosphorus, although not desired, may be tolerated if their content is maintained sufficiently low, ordinarily below 0.05%.

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The following table illustrates the improvement in mechanical resistance to stress at high temperatures resulting from a combination of titanium and boron, or a combination of columbium and boron, in austenitic stainless steels:

TABLE I

Time for rupture of austenitic stainless steels stressed to 40,000 lbs. per sq. in. at 1200° F.

[All specimens quenched in water from 2300° F. and tempered 1 hour at 1500° F.]

	1	2	3	4
C..... Per Cent..	0.07	0.07	0.08	0.07
Mn..... do.....	1.38	1.36	1.38	1.38
Si..... do.....	0.46	0.55	0.56	0.56
Ni..... do.....	12.65	11.36	11.15	11.15
Cr..... do.....	19.62	17.51	18.06	18.06
Ti..... do.....	0.57	0.53		
B..... do.....			0.029	0.027
Time for Rupture..... Hrs.	29	95	142	816
Elongation in 2 in..... Per Cent..	29	27	21	32

It will be observed that steel (specimen 2) which contains both titanium and boron withstands tensile stress without rupture for over three times the length of time which steel (specimen 1) containing titanium but no boron is capable of withstanding.

The table also shows that specimen 4, which contained both columbium and boron, withstood tensile stress without rupture for 816 hours and is greatly superior to specimen 3, which contained columbium but no boron, and withstood rupture stress for 142 hours.

The useful qualities of austenitic steels embodying our invention are illustrated further by the following data which exemplifies the properties of austenitic stainless steel having substantially the composition of specimen 2 of the preceding table, the titanium content, however, being 0.38% and the boron content being 0.02%.

TABLE II

Rockwell B hardness

Air-cooled from 2000° F., not tempered.....	53
Air-cooled from 2000° F., tempered 6 hrs. at 1200° F.....	87
Air-cooled from 2000° F., tempered 3 to 24 hrs. at 1300° F.....	92
Air-cooled from 2000° F., tempered 6 hrs. at 1400° F.....	89
Air-cooled from 2200° F., not tempered.....	70
Air-cooled from 2200° F., tempered 3 to 24 hrs. at 1300° F.....	91

Izod impact value, ft.-lbs.

Air-cooled from 2000° F., tempered 3 hrs. at 1300° F.----- 141

Air-cooled from 2000° F., tempered 16 hrs. at 1300° F.----- 142

Tensile properties at room temperature, with specimens 0.36 in. in diameter, air-cooled from 2000° F., tempered 3 hrs. at 1300° F.

Yield strength, 0.2% offset	lbs. per sq. in.	31,600
Tensile strength	do.	85,200
Elongation in 2 in.	per cent.	48
Reduction of area	do.	64.8

The alloy steel can be made by various known methods of stainless steel preparation, heat being supplied in any suitable fashion, although the alloys will preferably be prepared in arc or induction furnaces.

The alloying ingredients, nickel, chromium, titanium, columbium, boron, manganese, or other chosen alloying element, may be added to a fusion of low carbon steel conveniently, by adding suitable amounts of their ferro-alloys which have a predetermined content of the desired alloying elements.

In general, the high-temperature strength, tensile strength and hardness of austenitic alloys are improved in accordance with our invention by the incorporation therein and alloyage therewith of titanium in appreciable amounts, ordinarily about 0.02% and up to about 0.7%. Alternatively, columbium in appreciable amounts up to about 1% of columbium may replace the titanium in austenitic alloys and such metals may replace one another in part. In any case, the titanium, columbium, or other carbide formers mentioned, are associated with boron in the austenitic alloy in a substantial amount up to about 0.03% boron.

The heat treatment of the described alloys is critical and must be performed above about 1900 and preferably in the range 1900 to 2300° F., followed by quenching, to effect the necessary precipitation hardening.

The benefits of our invention, in providing steels capable of withstanding temperatures in the range of 800 to 1300° F., are of particular importance in power-generating apparatus as, for example, turbines and internal combustion en-

gines and in oil-refining apparatus and other branches of the chemical industry.

Although the principles of the invention have been illustrated with austenitic alloys of the chrome-nickel type, it will be understood that the invention is applicable to austenitic steels generally, whether the austenitic structure be induced by nickel or by other elements causing retention of austenite such as cobalt and manganese.

What is claimed is:

1. An austenitic alloy containing by weight about 17 to 19% of chromium, about 11 to 12% nickel, about 0.2 to 2% manganese, about 0.07% carbon, about 0.38 to 0.53% titanium and 0.01 to 0.10% boron, the balance being iron.

2. An austenitic alloy containing by weight about 18% chromium, about 11% nickel, about 1.38% manganese, about 0.56% silicon, about 0.07% carbon, about 0.89% columbium and 0.027% boron, the balance being iron.

3. An austenitic alloy containing by weight 0.03% to 0.10% carbon, from 4 to 15 times as much of one or more carbide formers selected from the group consisting of Ti, Cb, Ta and Zr, as carbon, and from 0.01 to 0.10% boron, 17% to 19% chromium, 11% to 12% nickel, 0.2% to 2.0% manganese, the balance being iron.

4. An austenitic alloy steel containing by weight 0.03 to 0.1% carbon, from 4 to 15 times as much titanium as carbon, and from 0.01% to 0.10% boron, 17% to 19% chromium, 11% to 12% nickel, 0.2% to 2.0% manganese, the balance being iron.

5. An austenitic alloy steel containing by weight 0.03 to 0.1% carbon, from 4 to 15 times as much columbium as carbon, and from 0.01% to 0.10% boron, 17% to 19% chromium, 11% to 12% nickel, 0.2% to 2.0% manganese, the balance being iron.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,990,590	Franks	Feb. 12, 1935
2,153,906	Aborn et al.	Apr. 11, 1939
2,159,497	Becket et al.	May 23, 1939
2,432,617	Franks et al.	Dec. 16, 1947