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2,848,323

FERRITIC STEEL FOR HIGH TEMPERATURE USE

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No Drawing. Application February 17, 1956
Serial No. 566,079

Claims priority, application Great Britain
February 28, 1955

12 Claims. (Cl. 75-124)

This invention relates to hardenable "ferritic" or martensitic (i. e. non-austenitic) chromium alloy steels.

Such alloy steels have been used to a large extent in recent years for creep-resistant applications, but there is a continual demand for improved creep strength.

Examples of development in this field are to be found in British Patents Nos. 638,110, 658,115, 730,272 and 733,146. It is known that in alloys of the kind in question containing from about 9% to about 20% chromium, additions of one or more of molybdenum, tungsten, vanadium, niobium or titanium are necessary if optimum creep strength is to be developed and that for most practical purposes the carbon content should preferably not exceed 0.3%. Under these conditions the alloy tends to become non-hardenable due to the additions of ferrite stabilisers which cause the alloy to have a high percentage of ferrite under equilibrium conditions at the hardening temperature (1050°-1250° C.).

The present invention provides means for maintaining hardenability while at the same time providing a comparatively high degree of creep strength.

It is known that nitrogen is an exceedingly potent stabiliser of austenite at 1050°-1250° C. causing suppression of the formation of ferrite under equilibrium conditions. However, the amount of nitrogen, which may be safely introduced into such steels is only about 0.06-0.10%, the larger additions only being feasible at the higher end of the chromium range of 9-20%. Higher nitrogen additions are in excess of solubility and cause the steel to outgas vigorously on solidification, which causes unsound ingots.

The basis of the present invention is the incorporation of specified proportions of aluminium in nitrogen-containing alloys of the kind in question. One of the effects of the presence of aluminium is that it permits an increase in the percentage of nitrogen which may safely be added to the alloy. Although in most cases increased nitrogen will be desirable, in some cases it may be sufficient to employ normal amounts of nitrogen while still retaining the presence of aluminium. The alloys according to this invention can be free from ferrite at the hardening temperature, although containing substantial quantities of one or more of molybdenum, tungsten, vanadium and titanium and are accordingly of excellent creep resistance, that is to say, having a creep strength of at least 30 tons per square inch at 500° C., based on a creep strain of 0.1% in 100 hours.

According to one feature the invention comprises alloys within the following ranges, the percentages being by weight:

Carbon	Percent
Carbon	0.05- 0.3
Manganese	0.1- 4

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	Percent
Silicon	0.1- 1
Chromium	9- 20
Tungsten and/or molybdenum	0.5- 10
Niobium and/or tantalum	0- 2
Vanadium	0- 2
Titanium	0- 2
Nitrogen	0.05- 0.3
Aluminium	0.05- 2
Boron	0-0.05
Nickel	0- 5
Cobalt	0- 15
Copper	0- 5
Iron and impurities	Balance

A more restricted range of alloys according to the invention comprises:

	Percent
Carbon	0.08- 0.25
Manganese	0.5- 1.5
Silicon	0.3- 0.7
Chromium	9- 13
Tungsten	0- 1
Molybdenum	0.4- 1.0
Vanadium	0.1- 0.5
Niobium and/or tantalum	0.2- 0.7
Titanium	0- 0.5
Nickel	0- 0.5
Nitrogen	0.05-0.15
Aluminium	0.05-0.15
Boron	0-0.03
Iron and impurities	Balance

A still more restricted range comprises:

	Percent
Carbon	0.08- 0.25
Manganese	0.5- 1.5
Silicon	0.3- 0.7
Chromium	9- 13
Tungsten	0.7- 2
Molybdenum	0.7- 2
Vanadium	0- 1
Niobium and/or tantalum	0- 1
Titanium	0- 0.5
Nickel	0- 1.0
Nitrogen	0.05-0.15
Aluminium	0.05-0.15
Boron	0-0.03
Cobalt	2- 10
Copper	0- 1.0
Iron and impurities	Balance

Examples of alloys according to the present invention are as follows:

	W.365	W.472	W.558
Carbon	0.08	0.1	0.12
Manganese	0.8	0.8	0.8
Silicon	0.3	0.4	0.4
Chromium	11	11	10.5
Cobalt			2.5
Tungsten		0.2	0.7
Molybdenum	0.5	0.5	0.7
Vanadium	0.2	0.2	0.7
Niobium	0.4	0.4	0.4
Boron	0.01	0.01	0.01
Nitrogen	0.1	0.125	0.1
Aluminium	0.2	0.1	0.05
Nickel		0.6	
Iron and impurities	Balance	Balance	Balance

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Further examples of alloys according to the present invention are as follows:

	W.559	W.560	W.600
Carbon	0.12	0.12	0.12
Manganese	0.8	1.2	1.3
Silicon	0.4	0.35	0.3
Chromium	10.5	10.5	10.5
Cobalt	2.5	2.5	5.0
Tungsten	0.7	0.8	1.0
Molybdenum	0.7	0.8	1.0
Vanadium	0.7	0.5	0.45
Niobium	0.4	0.45	0.45
Boron	0.01	0.01	0.01
Nitrogen	0.1	0.08	0.15
Aluminium	0.1	0.1	0.5
Nickel		0.6	
Iron and Impurities	Balance	Balance	Balance

Further examples of alloys according to the present invention are as follows:

	WEX 650	WEX 659	W.869
Carbon	0.12	0.12	0.07
Manganese	1.3	1.3	1.3
Silicon	0.3	0.3	0.3
Chromium	10.5	10.5	10.5
Cobalt	5.0	2.2	10
Tungsten	1.0	1.0	1.0
Molybdenum	1.0	1.0	1.0
Vanadium	0.45	0.45	0.45
Niobium	0.45	0.45	0.45
Boron	0.02	0.02	
Nitrogen	0.065	0.065	0.065
Aluminium	0.05	0.05	0.05
Nickel	0.8	1.7	
Iron and Impurities	Balance	Balance	Balance

What we claim is:

1. Alloys comprising the following ingredients within the ranges specified:

	Percent
Carbon	0.05-0.3
Manganese	0.1- 4
Silicon	0.1- 4
Chromium	9- 20
At least one metal of the group consisting of tungsten and molybdenum	0.5- 10
At least one metal of the group consisting of niobium and tantalum, when present	0- 2
Vanadium, when present	up to 2
Titanium, when present	up to 2
Nitrogen	0.05-0.3
Aluminium	0.05- 2
Boron, when present	up to 0.05
Nickel, when present	up to 5
Cobalt, when present	up to 15
Copper, when present	up to 5
Iron and impurities	Balance

2. Alloys comprising the following ingredients within the ranges specified:

	Percent
Carbon	0.08-0.25
Manganese	0.5- 1.5
Silicon	0.3- 0.7
Chromium	9- 13
Tungsten, when present	up to 1
Molybdenum	0.4- 1
Vanadium	0.1- 0.5
At least one metal of the group consisting of niobium and tantalum	0.2- 0.7
Titanium, when present	up to 0.5
Nickel, when present	up to 0.5
Nitrogen	0.05-0.15
Aluminium	0.05-0.15
Boron, when present	up to 0.03
Iron and impurities	Balance

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3. Alloys comprising the following ingredients within the ranges specified:

	Percent
Carbon	0.08-0.25
Manganese	0.5- 1.5
Silicon	0.3- 0.7
Chromium	9- 13
Tungsten	0.7- 2
Molybdenum	0.7- 2
Vanadium, when present	up to 1
At least one metal of the group consisting of niobium and tantalum, when present	up to 1
Titanium, when present	up to 0.5
Nickel, when present	up to 1
Nitrogen	0.05-0.15
Aluminium	0.05-0.15
Boron, when present	up to 0.03
Cobalt	2- 10
Copper, when present	up to 1
Iron and impurities	Balance

4. An alloy comprising:

	Percent
Carbon	0.08
Manganese	0.8
Silicon	0.3
Chromium	11
Molybdenum	0.5
Vanadium	0.2
Niobium	0.4
Boron	0.01
Nitrogen	0.1
Aluminium	0.2
Iron and impurities	Balance

5. An alloy comprising:

	Percent
Carbon	0.1
Manganese	0.8
Silicon	0.4
Chromium	11
Tungsten	0.2
Molybdenum	0.5
Vanadium	0.2
Niobium	0.4
Boron	0.01
Nitrogen	0.125
Aluminium	0.1
Nickel	0.6
Iron and impurities	Balance

6. An alloy comprising:

	Percent
Carbon	0.12
Manganese	0.8
Silicon	0.4
Chromium	10.5
Cobalt	2.5
Tungsten	0.7
Molybdenum	0.7
Vanadium	0.7
Niobium	0.4
Boron	0.01
Nitrogen	0.1
Aluminium	0.05
Iron and impurities	Balance

7. An alloy comprising:

	Percent
Carbon	0.12
Manganese	0.8
Silicon	0.4
Chromium	10.5
Cobalt	2.5
Tungsten	0.7
Molybdenum	0.7
Vanadium	0.7

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	Percent
Niobium -----	0.4
Boron -----	0.01
Nitrogen -----	0.1
Aluminium -----	0.1
Iron and impurities -----	Balance

8. An alloy comprising:

	Percent
Carbon -----	0.12
Manganese -----	1.2
Silicon -----	0.35
Chromium -----	10.5
Cobalt -----	2.5
Tungsten -----	0.8
Molybdenum -----	0.8
Vanadium -----	0.5
Niobium -----	0.45
Boron -----	0.01
Nitrogen -----	0.08
Aluminium -----	0.1
Nickel -----	0.6
Iron and impurities -----	Balance

9. An alloy comprising:

	Percent
Carbon -----	0.12
Manganese -----	1.3
Silicon -----	0.3
Chromium -----	10.5
Cobalt -----	5
Tungsten -----	1
Molybdenum -----	1
Vanadium -----	0.45
Niobium -----	0.45
Boron -----	0.01
Nitrogen -----	0.15
Aluminium -----	0.5
Iron and impurities -----	Balance

10. An alloy comprising:

	Percent
Carbon -----	0.12
Manganese -----	1.3
Silicon -----	0.3
Chromium -----	10.5
Cobalt -----	5
Tungsten -----	1
Molybdenum -----	1

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	Percent
Vanadium -----	0.45
Niobium -----	0.45
Boron -----	0.02
Nitrogen -----	0.065
Aluminium -----	0.05
Nickel -----	0.8
Iron and impurities -----	Balance

11. An alloy comprising:

	Percent
Carbon -----	0.12
Manganese -----	1.3
Silicon -----	0.3
Chromium -----	10.5
Cobalt -----	2.2
Tungsten -----	1
Molybdenum -----	1
Vanadium -----	0.45
Niobium -----	0.45
Boron -----	0.02
Nitrogen -----	0.065
Aluminium -----	0.05
Nickel -----	1.7
Iron and impurities -----	Balance

12. An alloy comprising:

	Percent
Carbon -----	0.07
Manganese -----	1.3
Silicon -----	0.3
Chromium -----	10.5
Cobalt -----	10
Tungsten -----	1
Molybdenum -----	1
Vanadium -----	0.45
Niobium -----	0.45
Nitrogen -----	0.065
Aluminium -----	0.05
Iron and impurities -----	Balance

References Cited in the file of this patent

UNITED STATES PATENTS

2,736,649	Phillips	Feb. 28, 1956
2,737,455	Kirkby	Mar. 6, 1956

FOREIGN PATENTS

970,873	France	Jan. 10, 1951
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