United States Patent [19]

Dalal et al.

[11] **3,793,011**

[45] **Feb. 19, 1974**

[54] **NICKEL BASE ALLOY**

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[22] Filed: **Nov. 8, 1971**

[21] Appl. No.: **196,799**

[52] **U.S. Cl.** **75/171**, 148/32.5

[51] **Int. Cl.** **C22c 19/00**

[58] **Field of Search** 75/171, 170; 148/32, 32.5

[56] **References Cited**

UNITED STATES PATENTS

3,619,182	11/1971	Bieber et al.	75/171
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[57] **ABSTRACT**

The alloys of this invention contain relatively small, but nonetheless significant, amounts of tungsten and molybdenum for solid solution strengthening, chromium for oxidation and sulfidation resistance, tantalum for solid solution and carbide strengthening, and aluminum and titanium to enhance the strength by precipitation of a fine dispersed phase, gamma prime $Ni_3(Al,Ti)$.

5 Claims, No Drawings

NICKEL BASE ALLOY

This invention relates to nickel base alloys exhibiting high strength, stability, ductility and resistance to corrosion, sulfidation and oxidation at elevated temperatures and which are useful for blades, vanes and integrally cast turbine wheels.

The alloys of this invention contain relatively small, but nonetheless significant, amounts of tungsten and molybdenum for solid solution strengthening, chromium for oxidation and sulfidation resistance, tantalum for solid solution and carbide strengthening, and aluminum and titanium to enhance the strength by precipitation of a fine dispersed phase, gamma prime $Ni_3(Al,Ti)$.

Compositions of the following analyses are contemplated as within the scope of the present invention, in weight percent, the balance being Ni except for incidental impurities:

C — 0.30 max.
Cr — 11–15
Co — 8–12
Mo — 1–2.5
W — 3–8
Ta — 4–10
Ti — 3.5–4.5
Al — 3–4
Ti + Al — 7–8
B — 0.005–0.025
Zr — 0.05–0.40

A more preferred range of compositions is as follows (in weight percent):

C — 0.10–0.22
Cr — 12.30–13.50

Co — 8.50–9.50
Mo — 1.85–2.05
W — 3.65–5.0
Ta — 4.5–8.0
Ti — 3.90–4.20
Al — 3.20–3.60
Ti + Al — 7.25–7.70
B — 0.010–0.020
Zr — 0.08–0.25
Ni — balance

Exemplary alloys in accordance with the teachings of this invention had the compositions shown in Table I which follows:

TABLE I

Heat No.	C	Cr	Co	Mo	W	Ta	Ti	Al	TiAl	B	Zr	Ni
I	.17	12.97	9.37	2.05	3.99	4.86	3.98	3.33	7.31	.014	.12	Balance
II	.17	12.97	9.37	2.05	3.99	5.86	3.98	3.33	7.31	.014	.12	Balance
III	.17	12.97	9.37	2.05	3.99	7.86	3.98	3.33	7.31	.014	.12	Balance
IV	.22	12.97	9.37	2.05	3.99	5.86	3.98	3.33	7.31	.014	.12	Balance
V	.22	12.97	9.37	2.05	3.99	7.86	3.98	3.33	7.31	.014	.12	Balance
VI	.20	12.31	9.18	1.94	3.72	6.70	4.08	3.38	7.46	.014	.15	Balance
VII	.17	12.97	9.37	2.05	5.00	4.86	3.98	3.33	7.31	.014	.15	Balance
VIII	.17	12.97	9.37	2.05	6.00	4.86	3.98	3.33	7.31	.014	.15	Balance

After vacuum melting, the alloys noted above were vacuum cast into ¼ inch ASTM test bars (ASTM E8) and subjected to stress rupture testing according to ASTM Standard E139. The test bars were heat treated before testing as follows: heated to 2,050°F, held at that temperature for 2 hours then air cooled, then reheated to 1,550°F and held at 1550°F for 4 hours, then air cooled, then reheated to 1,400°F and held at that temperature for 16 hours then air cooled.

After the heat treatment described above, stress rupture tests were conducted on cast test bars representative of each of the heats in the heat treated condition at 1,400°F/95Ksi, 1,400°F/100Ksi, 1,700°F/39Ksi and 1,800°F/29Ksi. The results are given in Table II.

TABLE II

	Stress Rupture Test Results (ASTM E139)							
	1400°F/95Ksi		1400°F/100Ksi		1700°F/39Ksi		1800°F/29Ksi	
Heat No.	Life (hrs.)	El (%)	Life (Hrs.)	El (%)	Life (Hrs.)	El (%)	Life (Hrs.)	El (%)
I					85	10	68	7
							80	5
II			190	5	181	5	67	11
					89	5		
IV			102	5	116	8	43	10
					130	6		
V			249	5	140	7	74	5

Corresponding values for two presently known commercial alloys are appended to Table II for comparison.

INCO 713C is reported to be an alloy with a nominal composition of

C	Cr	Mo	W	Cb	Ti	Al	Zr	B	Ni
0.14	13.0	4.5	0.20	2.0	0.75	5.75	0.05	0.012	Balance

MAR-M-421 is reported to be an alloy with a nominal composition of

C	Cr	Co	Mo	W	Cb	Ti	Al	Zr	B	Ni
0.15	15.8	9.5	2.0	3.8	2.0	1.8	4.3	0.05	0.015	Balance

From the results in Table II, the superiority of the alloys of this invention will be readily seen.

We claim:

1. A nickel base alloy exhibiting high strength, ductility, sulfidation and oxidation resistance and stability at elevated temperature and consisting essentially of the following in weight percent:

C—0.30 max.
Cr — 11–15.0
Co — 8–12
Mo — 1–2.5
W — 3.65–8
Ta— 4.5–10
Ti — 3.5–4.5
Al — 3–4
Ti + Al — 7–8
B — 0.005–0.025
Zr — 0.05–0.40
Ni — balance

2. A nickel base alloy exhibiting high strength, ductility, sulfidation and oxidation resistance and stability at elevated temperature and consisting essentially of the following in weight percent:

C — 0.10–0.22
Cr — 12.30–13.50
Co — 8.50–9.50
Mo — 1.85–2.05
W — 3.65–5.0
Ta — 4.5–8.0
Ti — 3.90–4.20
Al — 3.20–3.60
Ti + Al — 7.25–7.70
B — 0.010–0.020
Zr — 0.08–0.25
Ni — balance

3. A nickel base alloy according to claim **1** which has been heat treated to produce a desired morphology of carbides and gamma prime.

4. An article formed of the alloy of claim **1.**

5. A vacuum cast article consisting of the alloy of claim **1.**

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,793,011 Dated February 19, 1974

Inventor(s) Ranes P. Dalal et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Columns 1 and 2, Table II should appear as shown on the attached sheet.

Signed and sealed this 1st day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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TABLE II

Stress Rupture Test Results (ASTM E139)

Heat No.	1400°F/95Ksi Life (hrs.)	El (%)	1400°F/100Ksi Life (Hrs.)	El (%)	1700°F/39Ksi Life (Hrs.)	El (%)	1800°F/29Ksi Life (Hrs.)	El (%)
I					85	10	68	7
							80	5
II			190	5	181	5	67	11
					89	5		
IV			102	5	116	8	43	10
					130	6		
V			249	5	148	7	74	5
					149	7		
VI	131	5	-	-	172	6		
	195	5	-	-	117	5	61	6
					142	3		
					145	6		
INCO-713C	16	6	5	4	20	12		
MAR-M-421	50	3	20	3	15	15		
VII			189	8	133	8	56	10
			153	6	136	10		
VIII			158	3	144	8	56	5
					139	10	63	8