(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 944 704 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
06.07.2016 Bulletin 2016/27

(51) Int Cl.:
C22C 19/05 *(2006.01)*

(21) Application number: **15163869.9**

(22) Date of filing: **16.04.2015**

(54) NICKEL ALLOY COMPOSITION

NICKELLEGIERUNGSZUSAMMENSETZUNG

COMPOSITION D'ALLIAGE DE NICKEL

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **14.05.2014 GB 201408536**

(43) Date of publication of application:
18.11.2015 Bulletin 2015/47

(73) Proprietor: **Rolls-Royce plc**
London SW1E 6AT (GB)

(72) Inventors:
- **Conduit, Bryce**
  Derby, Derbyshire DE24 8BJ (GB)
- **Conduit, Gareth**
  Derby, Derbyshire DE24 8BJ (GB)
- **Stone, Howard**
  Derby, Derbyshire DE24 8BJ (GB)

(74) Representative: **Rolls-Royce plc**
Intellectual Property Dept SinA-48
PO Box 31
Derby DE24 8BJ (GB)

(56) References cited:
EP-A1- 1 065 290
EP-A2- 1 340 825
JP-A- 2001 073 053
US-A- 4 174 213
US-A- 5 480 283
US-A1- 2006 222 557

Printed by Jouve, 75001 PARIS (FR)

Description

Field of the Invention

[0001] The present invention relates to a nickel based alloy composition and a gas turbine engine component comprising a nickel based alloy.

Background to the Invention

[0002] Fig. 1 shows a high by pass ratio gas turbine engine 10. The engine 10 comprises an air intake 11 and a propulsive fan 12 that generates two airflows A and B. The gas turbine engine 10 comprises, in axial flow A, an intermediate pressure compressor 14, a high pressure compressor 16, a combustor 18, a high pressure turbine 20, an intermediate pressure turbine 22, a low pressure turbine 24 and an exhaust nozzle 26. A nacelle 30 surrounds the gas turbine engine 10 and defines, in axial flow B, a bypass duct 13.

[0003] The combustor 20 is shown in further detail in Fig. 2. The combustor comprises a combustor casing 32, within which is located a metal combustor liner 34. The combustor liner 34 is in turn covered in combustor liner tiles (not shown), which are made of a ceramic material. In use, air and fuel flow into the combustor 20, where the fuel is burned, producing hot combustion gases.

[0004] The combustor liner 34 must operate at high temperature in excess of 800°C (and perhaps as high as 900°C) for long periods of time. Higher combustion chamber temperature will result in higher thermal efficiencies of the gas turbine engine, and so this temperature must be made as high as possible through the use of high temperature alloys. High temperature alloys are also used in other parts of the engine, such as in the turbines and exhaust duct.

[0005] In order to permit operation at high temperatures, and provide a long service life, suitable alloys must also have a number of other properties, in addition to a high temperature capability. For example, they must have a high ultimate tensile strength, yield strength, stress rupture resistance, ductility, stability at high temperatures, resistance to thermal stresses, density and environmental resistance (e.g. resistance to hot corrosion and oxidation). In the art, the "stability" of an alloy is normally understood to refer to the alloy's propensity to precipitate detrimental phases (i.e. an alloy having a high stability will have a low propensity to precipitate detrimental phases). An example of a detrimental phase is the sigma (σ) phase, which can occur when the alloy is subjected to high temperatures for extended time periods (known as "dwell").

Table 1 below defines prior nickel based compositions suitable for use in combustor liners for gas turbine engines. All amounts are given in weight percentages.

Composition	Alloy described in US 4,174,213	Alloy described in US 4,080,201
Nickel (Ni)	42-70%	Balance
Chromium (Cr)	15-35%	12-18%
Cobalt (Co)	0.1/10%	<2%
Iron (Fe)	7.5 -35 %	0-3%
Manganese (Mn)	<2%	-
Tungsten (W)	0.1-10%	0-7%
Niobium (Nb)	0.05-1%	-
Tantalum (Ta)	-	<0.75%
Silicon (Si)	<2%	0.08%
Aluminium (Al)	-	0.5%
Titanium (Ti)	0.05-1%	0.75%
Carbon (C)	0.03-0.2%	0.02%
Molybdenum (Mo)	4.5-15%	10-18%

[0006] Other alloys used in combustor liners include Haynes 188™, Haynes 230™ and Nimonic 263™.

[0007] It is also desirable for the alloy composition to have a low cost (in terms of the elemental cost of the alloy), and low density (particularly where the combustor is for use in aerospace gas turbine engines) and be suitable for low cost production methods such as casting, wrought processing, powder metallurgy or direct laser deposition. It is also desirable that the final alloy is highly weldable (i.e. does not micro-segregate when melted), particularly where the alloy is to be used in direct laser deposition. Alloys having the above properties, and therefore being suitable for use in gas turbine engine components such as combustor liners, are generally known in the art as "superalloys", and are sometimes also referred to as "high performance alloys".

[0008] The present invention seeks to provide an improved alloy composition and an improved gas turbine engine component which solves some or all of the above problems.

Summary of the Invention

[0009] According to a first aspect of the present invention there is provided an alloy composition consisting essentially of, by weight per cent, between 18 and 20% chromium, between 8.5% and 12% cobalt, between 6.4 and 9.4% iron, up to 1.5% manganese, between 3.5 and 5.3% tungsten, up to 1.5% niobium, between 0.4% and 1 % tantalum, up to 1.5% silicon, between 1.5 and 2.3% aluminium, between 0.5 and 2.4% titanium, between 0.005 and 0.04% carbon, between 0.005 and 0.07% boron, and between 0.02 and 0.10% zirconium, optionally, up to 0.5% molybdenum, the balance being nickel and incidental impurities.

[0010] It has been found that the alloy composition of the present invention has a high strength at temperatures at around 900°C, and is also relatively lightweight, resistant to environmental degradation, inexpensive and suitable for conventional forming and machining processes. These properties make the alloy particularly suitable for use in gas turbine engine components such as combustor linings.

[0011] According to a second aspect of the invention, there is provided a component of a gas turbine engine formed of an alloy in accordance with the first aspect of the invention. According to a third aspect of the invention there is provided a gas turbine engine comprising a component according to the second aspect of the invention.

[0012] Accordingly, the invention provides a gas turbine engine having one or more components capable of operation at high temperatures. Consequently, the gas turbine engine can operate at a higher thermal efficiency, and hence lower specific fuel consumption, or may have a longer service life between overhauls, resulting in a lower operating cost.

[0013] Further features of the invention are described in the attached claims.

Brief Description of the Drawings

[0014] Embodiments of the invention are described and shown in the following drawings, in which:

Figure 1 shows a cross sectional view of a gas turbine engine;

Figure 2 shows a cross sectional view of part of the engine of Figure 1;

Figure 3 is a graph showing various properties of an alloy in accordance with the present disclosure plotted against temperature, compared to a prior alloy;

Figure 4 is a graph showing the maximum stress of both an alloy in accordance with the present disclosure and prior alloys, plotted against temperature;

Figure 5 is a graph showing the proportion of various phases in an alloy in accordance with the present disclosure, plotted against temperature;

Figure 6 is a graph showing the chromium activity of an alloy in accordance with the present disclosure compared with that of Nimonic 263™, plotted against temperature; and

Figure 7 is a scanning electron microscope image of a sample of an alloy in accordance with the present disclosure.

Detailed description of the Invention

[0015] Fig. 1 shows a high by pass ratio gas turbine engine 10. The engine 10 comprises an air intake 11 and a propulsive fan 12 that generates two airflows A and B. The gas turbine engine 10 comprises, in axial flow A, an intermediate pressure compressor 14, a high pressure compressor 16, a combustor 18, a high pressure turbine 20, an intermediate pressure turbine 22, a low pressure turbine 24 and an exhaust nozzle 26. A nacelle 30 surrounds the gas turbine engine 10 and defines, in axial flow B, a bypass duct 13.

[0016] The combustor 20 is shown in further detail in Fig. 2. The combustor comprises a combustor casing 32, within which is located a metal combustor liner 34. The combustor liner 34 is in turn covered in combustor liner tiles (not shown), which are made of a ceramic material. In use, air and fuel flow into the combustor 20, where the fuel is burned, producing hot combustion gases.

[0017] Table 2 shows a compositional range of an alloy in accordance with the disclosure, which is suitable for one or more components of the gas turbine engine 10 (and particularly suitable for use as the material of the combustor liner 34):

Table 2

wt.%	target	maximum	minimum
Ni	Balance	Balance	Balance
Cr	20.0-20.4	22	18.0
Co	9.3-11.3	12	8.5
Mo	0-0.2	0	0.5
Fe	7.4-8.4	9.4	6.4
Mn	0.2-0.4	1.5	0.0
W	4.2-4.6	5.3	3.5
Nb	1.0-1.2	1.5	0.0
Ta	0.6-0.8	1.0	0.4
Si	0.2-0.4	1.5	0
Al	1.8-2.0	2.3	1.5
Ti	1.6-1.8	2.4	0.5
C	0.015-0.025	0.04	0.005
B	0.015-0.025	0.04	0.005
Zr	0.05-0.07	0.10	0.02

[0018] Oxygen may also be present, in the form of surface oxides. Other incidental impurities may also be present in the alloy. In general, other impurities should be kept to a minimum, in particular sulphurous based impurities.

[0019] Various compositions can be produced using the maximum and minimum elemental quantities described in table 2. It has been found that all compositions within the bounds of the maximum and minimum quantities of table 2 result in alloys which have acceptable properties for use as a combustor liner 34.

[0020] The narrower target compositional range shown in table 2 has improved qualities over the alloy compositions lying outside this range, but within the wider range shown in the maximum and minimum columns. These minimum and maximum amounts are based upon sensitivity studies using a computational materials prediction tool which show the deviation of predicted properties with changing composition.

[0021] Table 3 below shows a nominal composition in accordance with the present disclosure (composition 1). The physical properties of this composition are described in further detail below.

Table 3

wt.%	Composition
Ni	Bal.
Cr	20.2
Co	10.3
Mo	0.1
Fe	7.9
Mn	0.3
W	4.4

(continued)

wt.%	Composition
Nb	1.1
Ta	0.7
Si	0.3
Al	1.9
Ti	1.7
C	0.015-0.025
B	0.015-0.025
Zr	0.06

[0022] Again, oxygen may also be present, in the form of surface oxides. Similarly, impurities may also be present.

[0023] The composition comprises nickel, which forms a continuous matrix comprising a face centred cubic (FCC) nickel based austenitic phase containing solid solution elements. The nickel based continuous matrix is known within the art as the "gamma (γ)" phase. Some of the alloying elements form a primary strengthening phase known as a "gamma prime (γ')" phase in an amount such that the volume fraction of the γ' is approximately 20% at 900°C. The γ' phase has the general formula Ni_3x, where x comprises elements selected from titanium, aluminium, tantalum and niobium, and usually comprises an ordered intermetallic L_{12} crystal structure. Formation of the γ' phase occurs in the solid state as the supersaturated solid solution of γ-nickel is cooled below its solvus temperature. Other elements (such as cobalt, iron, and tungsten) provide solid solution strengthening within the nickel matrix.

[0024] Some of the elements given in tables 2 and 3 partition to the gamma prime phase within the alloy. In this case, each of aluminium, titanium tantalum and niobium partition to the gamma phase. Though the relative amounts of each of these elements may vary between compositions within the scope of the present disclosure, the total amount of elements that partition to the gamma prime phase is between 6.5 and 8.5 atomic per cent. This has been found to contribute to the desirable properties of the disclosed alloy, in particular, ultimate tensile strength.

[0025] Some of the elements given in tables 2 and 3 partition to the gamma phase. Each of chromium, cobalt, iron, molybdenum and tungsten partition to the gamma phase. Again, the relative amounts of each of these elements may vary between compositions within the scope of the present disclosure. However, the total amount of elements that partition to the gamma phase is between 37 and 47 atomic per cent.

[0026] The alloy includes the following refractory (i.e. high melting temperature) alloys, which offer significant strengthening in the alloy at the temperatures at which gas turbine engines operate: tungsten, molybdenum, niobium and tantalum. These refractory alloys are included in amounts between 1.8 and 3.8 atomic per cent.

[0027] The chromium present in the composition is required to maintain a protective oxide scale on the surface of the billet (or finished component), providing resistance to oxidation, type I and II type hot corrosion, and dwell fatigue crack resistance. If the chromium content is too high (i.e. significantly above (20%), then the formation of deleterious phases is encouraged, which will impair the mechanical properties of the alloy.

[0028] Cobalt is added to provide additional solid solution strengthening to the gamma matrix and reduce the stacking fault energy. Cobalt can be added in comparatively large quantities (up to 12%) due to its compatibility with nickel. However, too much cobalt (i.e. significantly more than 12%) will increase the propensity to form deleterious phases in the alloy at the temperatures at which gas turbine engine components typically operate.

[0029] Iron has good solubility within the gamma phase, and is added as a solid solution strengthener. It has the additional benefits that it is low cost and decreases the density of the alloy, resulting in a lightweight, low cost alloy. However, an iron content that is too high (i.e. significantly above 10%) will promote the formation of the undesirable Laves phase at the temperatures at which gas turbine engines operate.

[0030] Tungsten is also added for its solid solution strengthening properties. Tungsten is thought to be a more potent solid solution strengthener than either cobalt or iron, but cannot be added in large quantities (i.e. at amounts significantly above 5.5%) due to the increased promotion of deleterious intermetallics, and its adverse effect upon the alloy's density. The amount of tungsten present in the composition is unusually high for a high temperature nickel based alloy, and has been found to greatly contribute to the high ultimate tensile strength of the alloy at high temperatures.

[0031] Niobium will partition to the gamma prime phase and provide strengthening, resisting the movement of dislocations through the gamma prime phase. However, the addition of too much niobium (i.e. significantly more than 1.5%) will result in the precipitation of the deleterious delta phase at the temperatures at which gas turbine components operate, which is not desired in the present invention. Niobium is also a potent metal carbide former (in conjunction with the carbon present in the alloy), which will improve dwell crack properties.

[0032] Tantalum is an effective gamma prime strengthener, preventing the movement of dislocations, which will give improved creep and other mechanical properties. The addition of tantalum will significantly increase the density and elemental cost of the alloy, which are both undesirable. However, unlike the other refractory metals, tantalum can be added in greater quantities before the alloy stability is compromised (up to 1 %). Tantalum is also a potent metal carbide former.

[0033] Silicon promotes the formation of a more stable and resistive oxide scale than chromium alone. However, its introduction leads to great instability in anything other than small quantities (i.e more than 1.5%), which has a significant impact upon the mechanical properties of articles formed from the alloy. While a large quantity of silicon suppresses formation of the deleterious eta phase, too much promotes the formation of the deleterious G phase.

[0034] Molybdenum is optionally present in the alloy. Molybdenum is postulated to have a positive effect on the environmental resistance of the alloy. It will also act as a solid solution strengthener but is more prone to promoting the formation of deleterious phases then other solid solution strengthening elements.

[0035] Aluminium is essential for promoting the formation of the gamma prime phase, which provides the major strengthening mechanism for the alloy. The control of its quantity is crucial to achieve the correct balance of properties (particularly in terms of the ratio of aluminium. Too much aluminium, and the alloy will be unprocessible (i.e., difficult to weld) - too little, and the alloy will have insufficient mechanical strength. In addition, aluminium will improve the oxidation resistance and lower the density of the alloy, which are both highly important considerations in aerospace gas turbine engine components.

[0036] Titanium will strengthen the gamma prime phase as well as increase the fraction of gamma prime present. It will also reduce the density of the alloy. The addition of too much titanium (i.e. significantly more than 2.4%) will promote the formation of the deleterious eta phase, promote the formation of too much gamma prime, and may compromise the environmental resistance of the alloy by increasing oxide thickening rates.

[0037] The aluminium to titanium ratio is generally greater than 1:1. This, along with a Cr/Ti ratio greater than 10:1, promotes a good oxidation and corrosion resistance. However, it is still recognised the significant strengthening benefit that Ti adds and unlike most other strengthening elements, it has no density penalty.

[0038] Carbon, boron and zirconium are added in small amounts (as shown in table 2) to form carbides and borides on the grain boundaries, which strengthen the grain boundaries of the alloys. Their amounts have been empirically optimised to prevent crack dwell fatigue and also prevent melt anomalies which will improve weldability.

[0039] The described alloy compositions can be used in various component manufacture methods, such as any of powder metallurgy methods, casting or laser deposition welding. The described alloy compositions are particularly suitable for laser deposition welding, since the alloy is highly stable, and does not tend to microsegregate when melted.

[0040] To generate a forging having the required balance of properties, it may be necessary to subject the forging to a heat treatment process. This heat treatment may be performed either above or below the gamma prime solvus temperature to obtain the desired gamma prime precipitate distribution. Optionally, this may be followed by an ageing treatment, which nominally would be 4-16 hours at 850-900 °C.

[0041] Various material properties of composition 1 are shown in Figs. 3 to 6.

[0042] Fig. 3 shows, plotted against temperature, the rupture stress, ultimate tensile stress, yield stress and design space (i.e. the minimum of the rupture stress, ultimate tensile stress (UTS), and yield stress) of composition 1 (labelled as "optimised combustor" on the graph), compared to equivalent values of Nimonic 263™. The design space essentially represents the maximum stress that can be applied to the alloy prior to a failure of some sort at a given temperature.

[0043] As can be seen, composition 1 has a higher predicted yield stress and stress rupture behaviour than Nimonic 263™, but a lower predicted UTS.

[0044] Fig. 4 compares the design space of composition 1 (again labelled as "optimised combustor alloy"), compared to Nimonic 263™, Haynes 282, Haynes 230 and Haynes 188. As can be seen, the design space of alloy composition 1 of the present disclosure is higher than all of the prior alloys at lower temperatures (less than 600°C), and only lower than Haynes 282 at higher temperatures.

[0045] However, it is thought that at these higher temperatures, the thermal stresses in Haynes 282 will be higher than those in composition 1. Consequently, the alloy of the present disclosure will be able to operate at higher temperatures than even Haynes 282.

[0046] The merit of an alloy, P to resist thermal stresses can be given as the following merit index:

$$P = \frac{\sigma_{YS}}{E\rho\alpha}$$

Where σ_{YS} is the yield stress, E is the Young's modulus, ρ is the resistivity and α is the thermal expansivity. Accordingly, the alloy of the present invention is predicted to have a high resistance to thermal stress.

[0047] Fig. 5 shows the relative molar fractions of various phases in composition 1, as plotted against temperature. As can be seen, at temperatures around 900°C, substantially only gamma and gamma prime are present. No precipitation of sigma (σ) is observed, demonstrating that the desired level of microstructural stability has been achieved for use as an alloy that can be formed by direct laser deposition, and used as a combustor liner material.
[0048] Fig. 6 shows the activity of chromium of the alloy of composition 1, plotted as a function of temperature, in comparison to that of Nimonic 263. As can been seen, the chromium activity of the alloy of composition 1 is significantly higher, resulting in better environmental resistance (i.e. approximately half the oxidation rate of Nimonic 263).
[0049] Fig. 7 shows an image from a scanning electron microscope of the alloy of composition 1 after is has been subject to temperatures of 750°C for 1000 hours. As can be seen, there is substantially no microstructural segregation or cracking. Consequently, the alloy is resistant to high dwell temperatures.
[0050] Primarily this alloy is intended to be manufactured using direct laser deposition, however it is also suitable for other commonly used manufacturing techniques such as casting, powder processing and welding.
[0051] Consequently, the disclosed compositions describe alloys which possess a number of advantageous properties compared to prior alloys. In summary, the main advantages of the new alloy in comparison to the prior art are:

1. better mechanical properties, particularly at temperatures above 800 °C;
2. higher stablility with respect to the formation of deleterious phases;
3. lower elemental cost and lower density;
4. lower thermal stress;
5. higher chromium activity leading to superior corrosion and oxidation properties;
6. properties that better suit all of the requirements of a combustor liner alloy; and
7. higher amenability to thermomechanical processing and additive manufacture.

[0052] Although the description refers to the described alloys as being particularly useful for forming combustor linings for gas turbine engines, the alloys could also be used to form other components.
[0053] Although the alloy is described as being subjected to heat treatment, other material processing methods could be used to generate articles from the alloy compositions having the required properties.

Claims

1. An alloy consisting of, by weight per cent, between 18 and 20% chromium, between 8.5% and 12% cobalt, between 6.4 and 9.4% iron, up to 1.5% manganese, between 3.5 and 5.3% tungsten, up to 1.5% niobium, between 0.4% and 1% tantalum, up to 1.5% silicon, between 1.5 and 2.3% aluminium, between 0.5 and 2.4% titanium, between 0.005 and 0.04% carbon, between 0.005 and 0.07% boron, and between 0.02 and 0.10% zirconium, optionally, up to 0.5% molybdenum, the balance being nickel save for incidental impurities.

2. An alloy according to claim 1, wherein the alloy consists of, by weight per cent, between 18 and 20% chromium, between 8.5% and 12% cobalt, between 6.4 and 9.4% iron, up to 1.5% manganese, between 3.5 and 5.3% tungsten, up to 1.5% niobium, between 0.4% and 1% tantalum, between 0.1% and 1.5% silicon, between 1.5 and 2.3% aluminium, between 1 and 2.4% titanium, between 0.005 and 0.04% carbon, between 0.005 and 0.07% boron, and between 0.02 and 0.10% zirconium, the balance being nickel save for incidental impurities.

3. An alloy according to claim 1, wherein the alloy comprises between 0.1% and 1.5% by weight silicon.

4. An alloy composition according to claim 1 or claim 2, wherein the alloy consists of, by weight per cent, 20% chromium, between 9.3% and 11.3% cobalt, between 7.4 and 8.4% iron, between 0.2 and 0.4% manganese, between 4.2 and 4.6% tungsten, between 1 and 1.2% niobium, between 0.6% and 0.8% tantalum, between 0.2 and 0.4% silicon, between 1.8 and 2.0% aluminium, between 1.6 and 1.8% titanium, between 0.015 and 0.025% carbon, between 0.015 and 0.025% boron, and between 0.05 and 0.07% zirconium, the balance being nickel save for incidental impurities.

5. An alloy composition according to any of the preceding claims, wherein the alloy consists of by weight per cent, 20% chromium, 10.3% cobalt, 7.9% iron, 0.3% manganese, 4.4% tungsten, 1.1% niobium, 0.7% tantalum, 0.3% silicon, 1.9% aluminium, 1.7% titanium, between 0.015 and 0.025% carbon, between 0.015 and 0.025% boron, and between 0.05 and 0.07% zirconium, the balance being nickel save for incidental impurities.

6. An alloy according to any of the preceding claims, wherein the incidental impurities include oxygen.

7. An alloy according to claim 1 or claim 2, wherein the ratio by weight of titanium to aluminium is less than 0.5.

8. An alloy according to any of the preceding claims, wherein the ratio by weight of chromium to titanium is greater than 10.

9. A gas turbine engine component formed of an alloy in accordance with any of the preceding claims.

10. A gas turbine engine component according to claim 9, wherein the component comprises a combustor liner.

11. A gas turbine engine comprising a component according to claim 9 or claim 10.

Patentansprüche

1. Legierung, bestehend aus zwischen 18 und 20 Gew.-% Chrom, zwischen 8,5 Gew.-% und 12 Gew.-% Kobalt, zwischen 6,4 und 9,4 Gew.-% Eisen, bis zu 1,5 Gew.-% Mangan, zwischen 3,5 und 5,3 Gew.-% Wolfram, bis zu 1,5 Gew.-% Niob, zwischen 0,4 Gew.-% und 1 Gew.-% Tantal, bis zu 1,5 Gew.-% Silizium, zwischen 1,5 und 2,3 Gew.-% Aluminium, zwischen 0,5 und 2,4 Gew.-% Titan, zwischen 0,005 und 0,04 Gew.-% Kohlenstoff, zwischen 0,005 und 0,07 Gew.-% Bor und zwischen 0,02 und 0,10 Gew.-% Zirconium sowie gegebenenfalls bis zu 0,5 Gew.-% Molybdän, wobei der Rest vor zufälligen Unreinheiten sicheres Nickel ist.

2. Legierung nach Anspruch 1, wobei die Legierung aus zwischen 18 und 20 Gew.-% Chrom, zwischen 8,5 Gew.-% und 12 Gew.-% Kobalt, zwischen 6,4 und 9,4 Gew.-% Eisen, bis zu 1,5 Gew.-% Mangan, zwischen 3,5 und 5,3 Gew.-% Wolfram, bis zu 1,5 Gew.-% Niob, zwischen 0,4 Gew.-% und 1 Gew.-% Tantal, zwischen 0,1 Gew.-% und 1,5 Gew.-% Silizium, zwischen 1,5 und 2,3 Gew.-% Aluminium, zwischen 1 und 2,4 Gew.-% Titan, zwischen 0,005 und 0,04 Gew.-% Kohlenstoff, zwischen 0,005 und 0,07 Gew.-% Bor sowie zwischen 0,02 und 0,10 Gew.-% Zirconium besteht, wobei der Rest vor zufälligen Unreinheiten sicheres Nickel ist.

3. Legierung nach Anspruch 1, wobei die Legierung zwischen 0,1 und 1,5 Gew.-% Silizium umfasst.

4. Legierungszusammensetzung nach Anspruch 1 oder Anspruch 2, wobei die Legierung aus 20 Gew.-% Chrom, zwischen 9,3 Gew.-% und 11,3 Gew.-% Kobalt, zwischen 7,4 und 8,4 Gew.-% Eisen, zwischen 0,2 und 0,4 Gew.-% Mangan, zwischen 4,2 und 4,6 Gew.-% Wolfram, zwischen 1 und 1,2 Gew.-% Niob, zwischen 0,6 Gew.-% und 0,8 Gew.-% Tantal, zwischen 0,2 und 0,4 Gew.-% Silizium, zwischen 1,8 und 2,0 Gew.-% Aluminium, zwischen 1,6 und 1,8 Gew.-% Titan, zwischen 0,015 und 0,025 Gew.-% Kohlenstoff, zwischen 0,015 und 0,025 Gew.-% Bor sowie zwischen 0,05 und 0,07 Gew.-% Zirconium besteht, wobei der Rest vor zufälligen Unreinheiten sicheres Nickel ist.

5. Legierungszusammensetzung nach einem der vorhergehenden Ansprüche, wobei die Legierung aus 20 Gew.-% Chrom, 10,3 Gew.-% Kobalt, 7,9 Gew.-% Eisen, 0,3 Gew.-% Mangan, 4,4 Gew.-% Wolfram, 1,1 Gew.-% Niob, 0,7 Gew.-% Tantal, 0,3 Gew.-% Silizium, 1,9 Gew.-% Aluminium, 1,7 Gew.-% Titan, zwischen 0,015 und 0,025 Gew.-% Kohlenstoff, zwischen 0,015 und 0,025 Gew.-% Bor sowie zwischen 0,05 und 0,07 Gew.-% Zirconium besteht, wobei der Rest vor zufälligen Unreinheiten sicheres Nickel ist.

6. Legierung nach einem der vorhergehenden Ansprüche, wobei die zufälligen Unreinheiten Sauerstoff umfassen.

7. Legierung nach Anspruch 1 oder Anspruch 2, wobei das Gewichtsverhältnis zwischen Titan und Aluminium kleiner ist als 0,5.

8. Legierung nach einem der vorhergehenden Ansprüche, wobei das Gewichtsverhältnis zwischen Chrom und Titan größer ist als 10.

9. Gasturbinentriebwerkskomponente, die aus einer Legierung gemäß einem der vorhergehenden Ansprüche gebildet ist.

10. Gasturbinentriebwerkskomponente nach Anspruch 9, wobei die Komponente eine Brennkammerauskleidung umfasst.

11. Gasturbinentriebwerk, umfassend eine Komponente nach Anspruch 9 oder Anspruch 10.

Revendications

1. Alliage, constitué de, en pourcentage pondéral, entre 18 et 20 % de chrome, entre 8,5 % et 12 % de cobalt, entre 6,4 et 9,4 % de fer, jusqu'à 1,5 % de manganèse, entre 3,5 et 5,3 % de tungstène, jusqu'à 1,5 % de niobium, entre 0,4 % et 1 % de tantale, jusqu'à 1,5 % de silicone, entre 1,5 et 2,3 % d'aluminium, entre 0,5 et 2,4 % de titane, entre 0,005 et 0,04 % de carbone, entre 0,005 et 0,07 % de bore et entre 0,02 et 0,10 % de zirconium, facultativement, jusqu'à 0,5 % de molybdène, le reste étant constitué de nickel à l'exception des impuretés fortuites.

2. Alliage selon la revendication 1, l'alliage étant constitué de, en pourcentage pondéral, entre 18 et 20 % de chrome, entre 8,5 % et 12 % de cobalt, entre 6,4 et 9,4 % de fer, jusqu'à 1,5 % de manganèse, entre 3,5 et 5,3 % de tungstène, jusqu'à 1,5 % de niobium, entre 0,4 % et 1 % de tantale, entre 0,1 % et 1,5 % de silicone, entre 1,5 et 2,3 % d'aluminium, entre 1 et 2,4 % de titane, entre 0,005 et 0,04 % de carbone, entre 0,005 et 0,07 % de bore et entre 0,02 et 0,10 % de zirconium, le reste étant constitué de nickel à l'exception des impuretés fortuites.

3. Alliage selon la revendication 1, l'alliage comprenant entre 0,1 % et 1,5 % en poids de silicone.

4. Composition d'alliage selon la revendication 1 ou la revendication 2, l'alliage étant constitué de, en pourcentage pondéral, 20 % de chrome, entre 9,3 % et 11,3 % de cobalt, entre 7,4 et 8,4 % de fer, entre 0,2 et 0,4 % de manganèse, entre 4,2 et 4,6 % de tungstène, entre 1 et 1,2 % de niobium, entre 0,6 % et 0,8 % de tantale, entre 0,2 et 0,4 % de silicone, entre 1,8 et 2,0 % d'aluminium, entre 1,6 et 1,8 % de titane, entre 0,015 et 0,025 % de carbone, entre 0,015 et 0,025 % de bore et entre 0,05 et 0,07 % de zirconium, le reste étant constitué de nickel à l'exception des impuretés fortuites.

5. Composition d'alliage selon l'une quelconque des revendications précédentes, l'alliage étant constitué de, en pourcentage pondéral, 20 % de chrome, 10,3 % de cobalt, 7,9 % de fer, 0,3 % de manganèse, 4,4 % de tungstène, 1,1 % de niobium, entre 0,7 % de tantale, 0,3 % de silicone, 1,9 % d'aluminium, 1,7 % de titane, entre 0,015 et 0,025 % de carbone, entre 0,015 et 0,025 % de bore et entre 0,05 et 0,07 % de zirconium, le reste étant constitué de nickel à l'exception des impuretés fortuites.

6. Alliage selon l'une quelconque des revendications précédentes, dans lequel les impuretés fortuites sont notamment de l'oxygène.

7. Alliage selon la revendication 1 ou la revendication 2, dans lequel le rapport en poids du titane à l'aluminium est inférieur à 0,5.

8. Alliage selon l'une quelconque des revendications précédentes, dans lequel le rapport en poids du chrome au titane est supérieur à 10.

9. Composant de turbine à gaz constitué d'un alliage selon l'une quelconque des revendications précédentes.

10. Composant de turbine à gaz selon la revendication 9, le composant comprenant une chemise thermique.

11. Turbine à gaz comprenant un composant selon la revendication 9 ou la revendication 10.

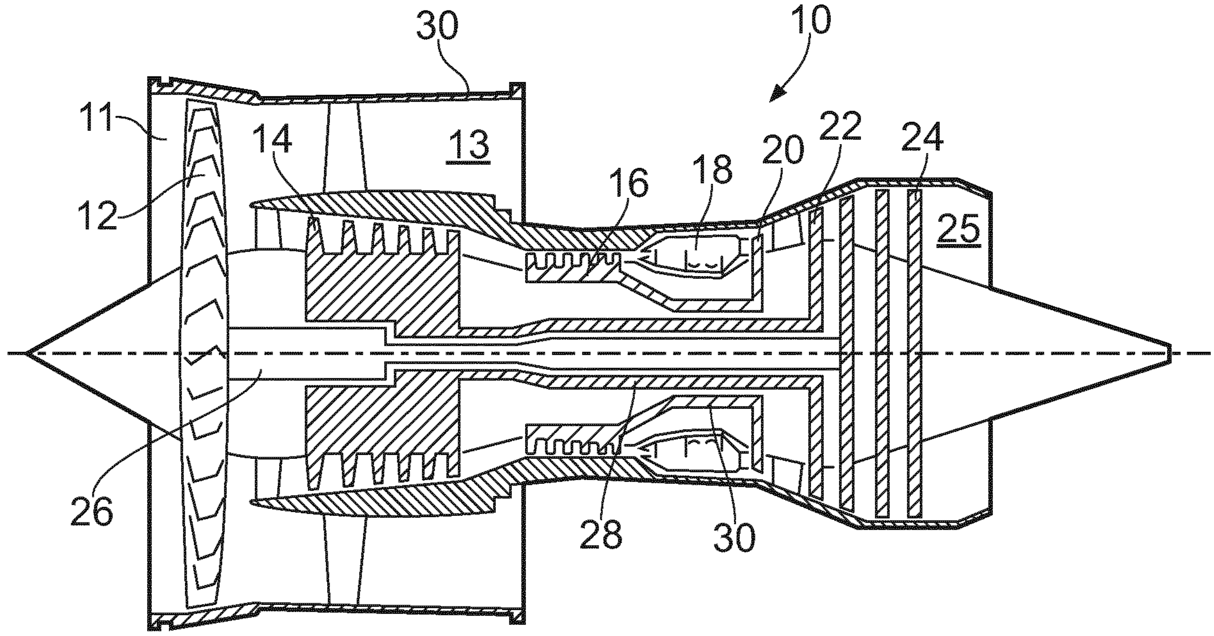

FIG. 1

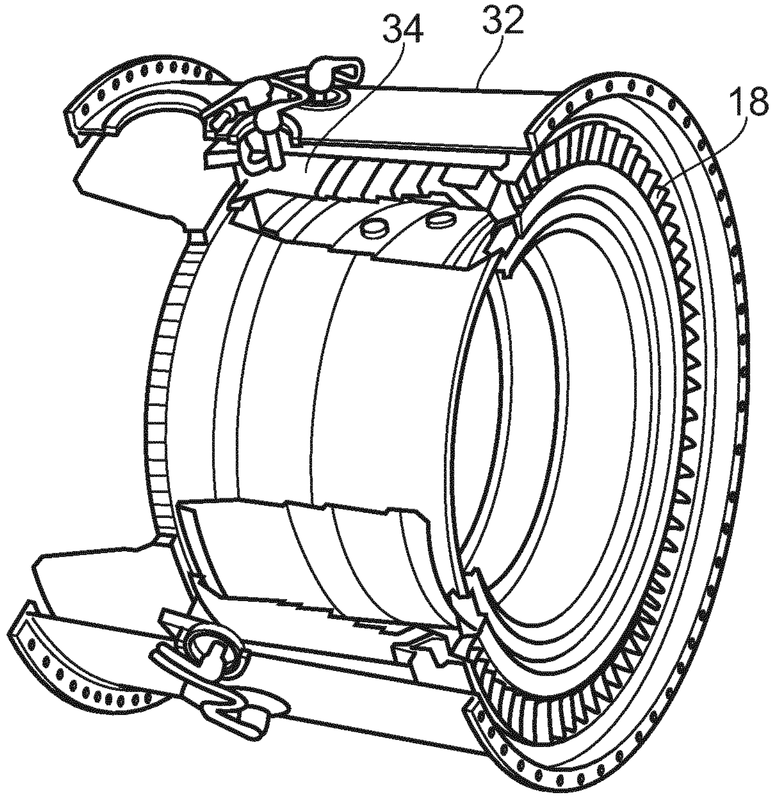

FIG. 2

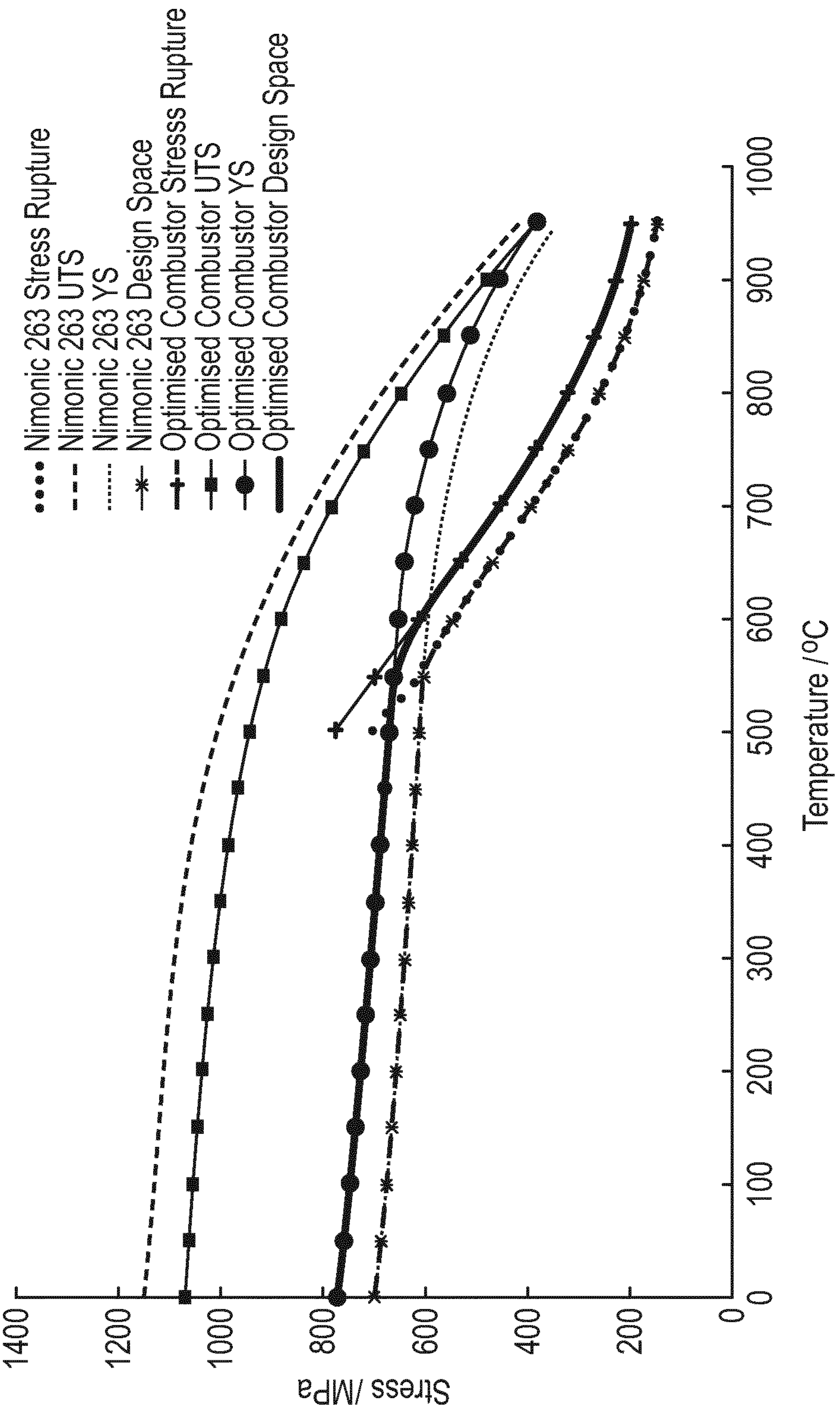
Nimonic 263 Stress Rupture
Nimonic 263 UTS
Nimonic 263 YS
Nimonic 263 Design Space
Optimised Combustor Stresss Rupture
Optimised Combustor UTS
Optimised Combustor YS
Optimised Combustor Design Space
Stress /MPa
1400
1200
1000
800
600
400
200
0
Temperature /ºC
0
100
200
300
400
500
600
700
800
900
1000

FIG. 3

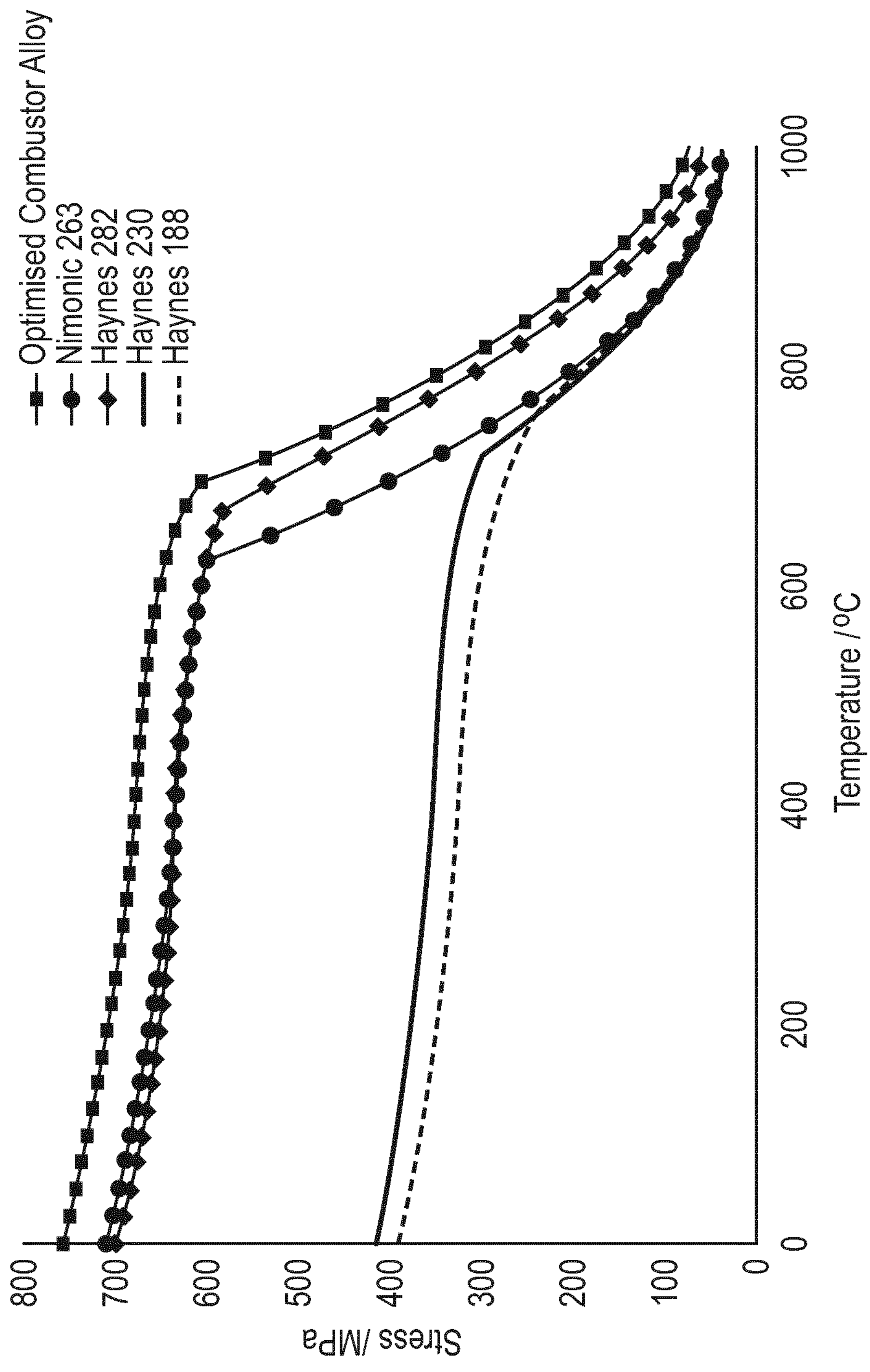
Optimised Combustor Alloy
Nimonic 263
Haynes 282
Haynes 230
Haynes 188
Stress /MPa
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
Temperature /ºC

FIG. 4

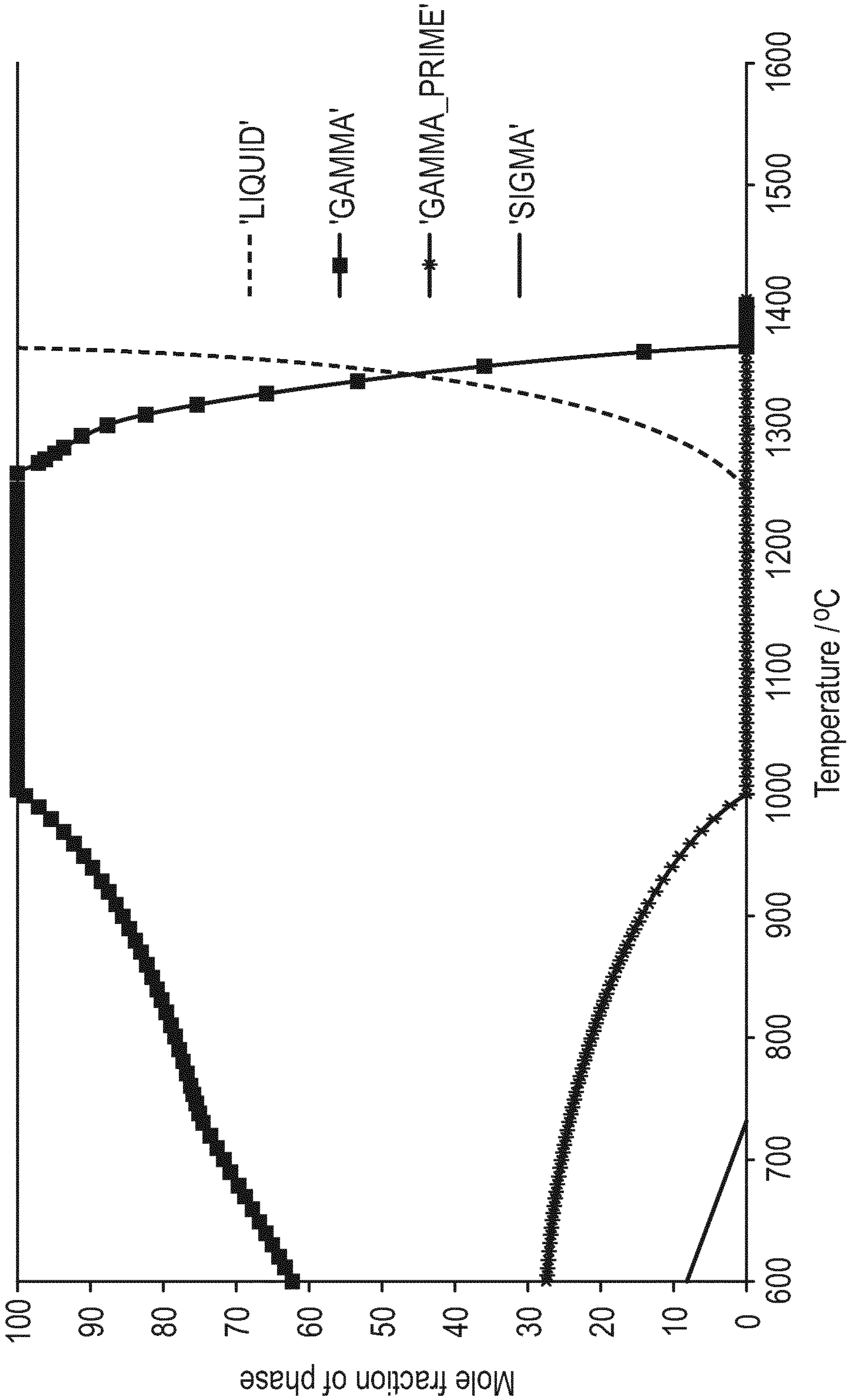
'LIQUID'
'GAMMA'
'GAMMA_PRIME'
'SIGMA'
Mole fraction of phase
0
10
20
30
40
50
60
70
80
90
100
Temperature /oC
600
700
800
900
1000
1100
1200
1300
1400
1500
1600

FIG. 5

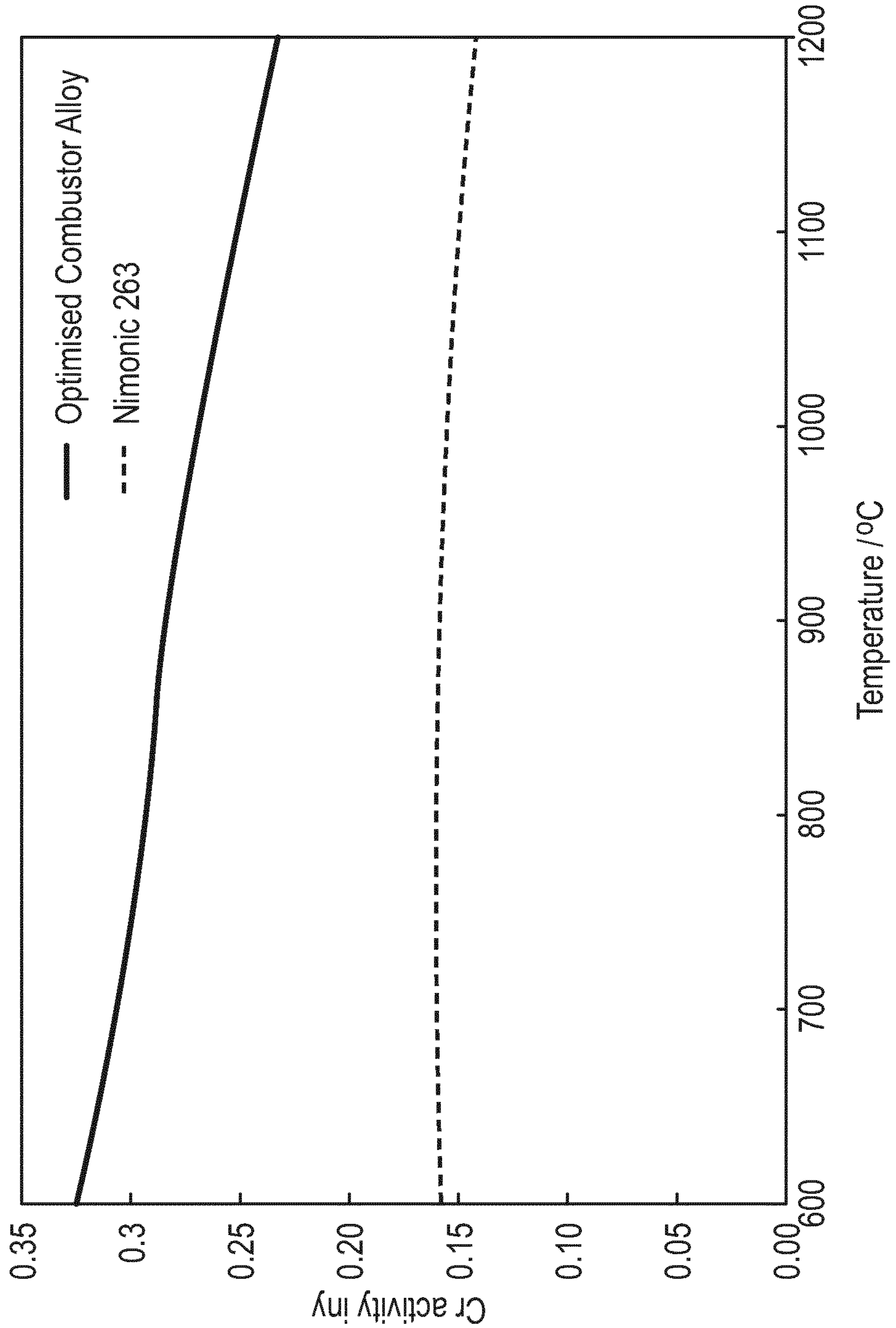
Optimised Combustor Alloy
Nimonic 263
Cr activity iny
0.00
0.05
0.10
0.15
0.20
0.25
0.3
0.35
600
700
800
900
1000
1100
1200
Temperature /ºC

FIG. 6

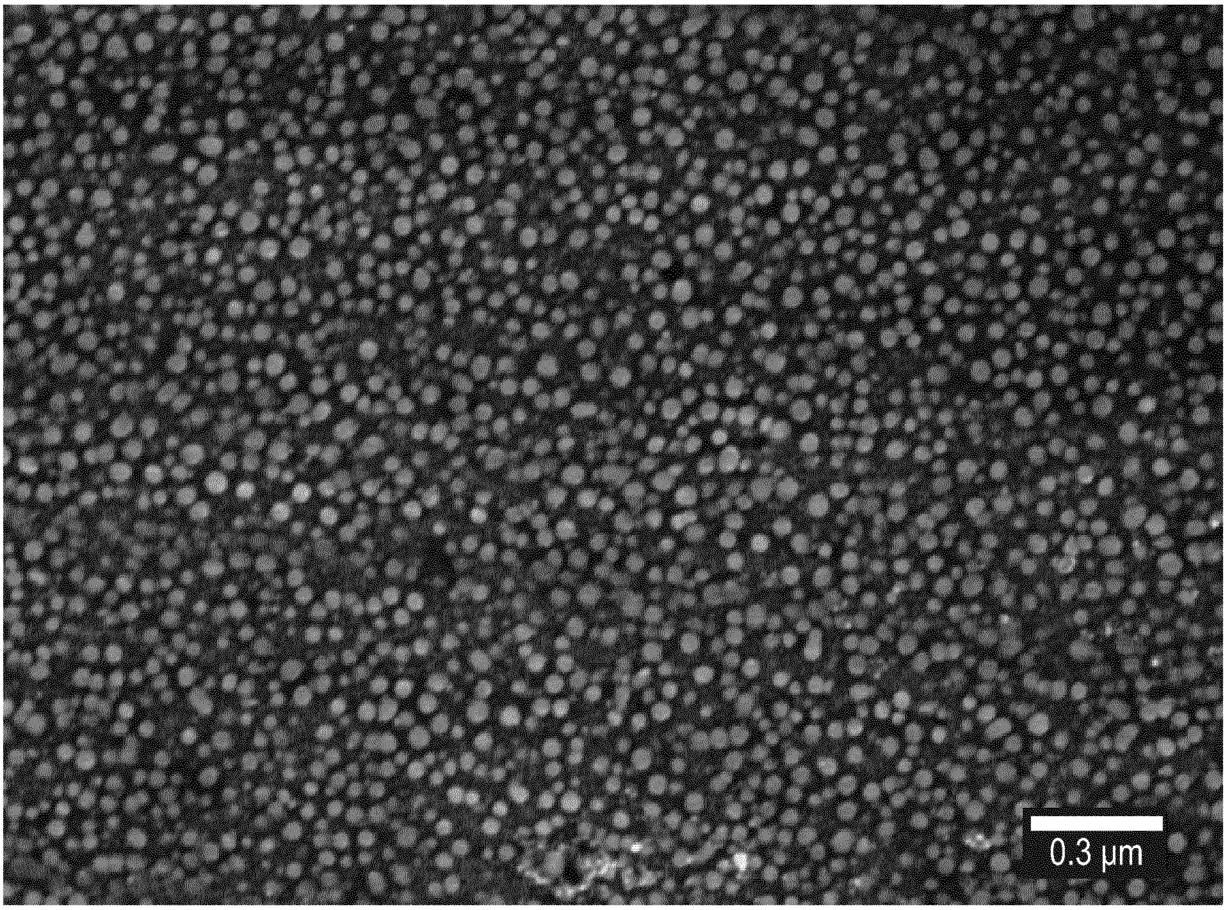

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4174213 A **[0005]**
- US 4080201 A **[0005]**