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[54] **HIGH-TEMPERATURE ALLOYS AND ARTICLES**
3 Claims, No Drawings

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

[56] **References Cited**

UNITED STATES PATENTS

1,572,996	2/1926	Girin	75/171
2,396,552	3/1946	Cape	75/171
2,540,107	2/1951	English et al.	75/171
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ABSTRACT: A new high-temperature alloy having high creep resistance and improved load fracture properties at temperatures of 2,000° F. and above comprising about 0.35% to 0.75% carbon, at least about 0.2% manganese, up to about 2% silicon, about 40% to 55% nickel, about 22% to 33% chromium, about 4% to 6% tungsten, about 1% to 4.5% cobalt and the balance iron with usual impurities in ordinary amounts.

HIGH-TEMPERATURE ALLOYS AND ARTICLES

This application is a continuation-in-part of out copending application Ser. No. 623,746 filed Mar. 16, 1967 now abandoned.

This invention relates to high-temperature alloys and articles and particularly to high-temperature alloys having a unique balance of load resistance to elongation at elevated temperatures. There has been a continual demand for alloys having high creep resistance. The fields of high-temperature furnace components such as radiant tubes and shafts, gas turbines, jet engines, crucibles, internal combustion engines and turbo superchargers are but a few of the fields in which such materials are useful. Various alloys have heretofore been proposed having various compositions and areas of usefulness but in general all such alloys have some drawbacks. One alloy which has been successfully used in a variety of instances which high load resistance and creep were essential, particularly in combination with resistance to corrosion in oxygen, is that disclosed and claimed in out U.S. Pat. No. 2,540,107 and sold by Blaw-Knox Company under the trademark "22H."

The present alloy is markedly superior to 22H in limiting creep stress values at 2,000° F. and in increasing the load fracture time at temperatures above 2,100° F. For example at 2,000° F. the limiting creep stress (1 percent elongation in 10,000 hours) for 22H is 1,050 p.s.i. whereas for the present alloy it is 1,600 p.s.i. At 2,100° F., at a 700 p.s.i. load the sample of 22H failed at 1,200 hours whereas the present alloy was tested for 3,080 hours and still remained intact when the test was stopped. The 1,900° F. limiting creep stress to produce 1 percent elongation in 10,000 hours for 22H is 1,200 p.s.i. and for the present alloy is 2,000 p.s.i.

Properties which are important in materials for this purpose are resistance to oxidation and stability of shape under load. As the temperatures increase, metals tend to burn more readily and also to have greater plastic deformation or creep over a period of time. Many metals which might be quite strong at high temperatures cannot be exposed to even mildly corrosive or oxidizing atmospheres at such temperatures without rapidly being consumed, while other compositions which are resistant to burning do not have rigidity.

Corrosion of alloys in hot gases is dependent, of course, on the atmosphere as well as the alloy. The behavior of metals maintained constantly under high temperature is characteristically a progressive burning away of the surface at a substantially constant rate, which is measured in inches penetration per year.

The behavior of specimen metals under constant stress below the elastic limit at high temperature is characterized by three stages of deformation, namely:

1. A period of internal stress distribution taking place in a relatively short time and characterized by an initial high and diminishing rate of deformation. This stage is made up of elastic and plastic flow.

2. A period of constant rate of deformation lasting over long periods of time. This phenomenon is known to metallurgists as creep, and is usually measured in terms of elongation per hour under a given tension, although it is equally characteristic of other deformations and we prefer to compare specimens in bending rather than in direct tension, and to express creep in terms of angular deflections per hour.

3. A final increasing rate of deformation leading to necking and failure.

The rate of deformation per unit time in stage 2 is a suitable measure of rigidity or permanence of shape of the material at the load and temperature. It is customary to select the allowable unit stress for a particular metal at a particular high temperature on the basis of the creep considered permissible at that temperature. The time to reach and pass through the different stages to creep is of importance and is influenced by the material, temperature and load or unit stress.

Our alloy has high mechanical strength, low creep and also high resistance to corrosion at very high temperatures in the as cast condition without heat treatment, age hardening or any of the like treatments. The material can, however, be further worked and treated if desired. Our alloy is equal or superior in these respects to other known alloys at lower temperatures, its relative advantages and superiority become strikingly apparent at the higher temperatures for which it is peculiarly adaptable; e.g. at temperatures such as 2,300° F. It is an alloy of nickel containing as essential alloying constituents chromium, tungsten, cobalt and carbon, the balance being substantially iron along with the controlled amounts of manganese and silicon and the usual impurities in ordinary amounts. We have found that cobalt additions, previously considered deleterious, are in the narrow range of out invention actually beneficial. Peculiarly higher amounts of cobalt causes embrittlement of the alloy on cooling from high temperatures while lower amounts reduce the corrosion resistance without affecting any significant improvement in other areas.

The alloy of the present would have in a preferred embodiment the following composition:

Carbon	0.45
Manganese	1.25
Silicon	0.75
Nickel	48.0
Chromium	27.0
Tungsten	5.0
Cobalt	3.0
Iron	— Balance with usual impurities.

Our alloy may, however, extend over a range and still retain its desirable and unique characteristics. Such a range would be as follows:

C	0.35	0.75
Mn–at least		0.2
Si–up to about		2.0%
Ni	40	55
Cr	22	33
Co	1	4.5
W	4	6
Fe	— Balance with usual impurities.	

The uniqueness of the invention can perhaps best be understood by reference to the following test data comparing 22H with the present alloy:

TABLE I

Stress Rupture Data

	Temp.	Stress	Creep Rate	
22H	2,100° F.	700 p.s.i.	0.0024%/hr.	1,270 hrs. to fracture
Alloy of Invention	2,100° F.	700 p.s.i.	0.0003%/hr.	3,080 hrs. No test discontinued

TABLE II.—ANALYSIS

Alloy	C	Mn	Si	Ni	Cr	W	Co
22H	0.57	1.23	1.08	48.9	26.1	6.16	-----
Alloy of invention	0.60	0.38	1.07	51.0	25.7	6.10	2

A series of tests were run to check the effect of varying cobalt concentrations while maintaining the balance of alloy substantially constant. The results are tabulated below and are illustrated in the accompanying Figure:

TABLE III

Co	Temp.	Cantilever Load	Radians/hr.
	2,200	500	0.000100
2.4	2,200	500	0.000044
4.5	2,200	500	0.000050
5.8	2,200	500	0.000056
2.0	2,200	500	0.000050

While we have described and disclosed a preferred embodiment of our invention, it will be understood that this invention may be otherwise embodied within the scope of the following claims.

We claim:

1. An alloy having new creep and load fracture properties at very high temperature in the range of 2,000° F. and above consisting of about 0.35% to 0.75% carbon, at least about 0.2% manganese, up to about 2% silicon, about 40% to 55% nickel, about 27% to 33% chromium, about 4% to 6% tungsten, about 2% to 4.5% cobalt and the balance iron with ordinary impurities in usual amounts.

2. The alloy as claimed in claim 1 wherein the carbon is 0.45%, manganese 1.25%, silicon 0.75%, nickel 48%, chromium 27%, tungsten 5%, cobalt 3% and the balance iron with ordinary impurities in usual amounts.

3. A refractory metal furnace part having high creep and load fracture properties cast from an alloy consisting of about 0.35% to 0.75% carbon, at least about 0.2% manganese, up to about 2% silicon, about 40% to 55% nickel, about 27% to 33% chromium, about 4% to 6% tungsten, about 2% to 4.5% cobalt and the balance iron with usual impurities in ordinary amounts and characterized by creep resistance, corrosion resistance and improved load fracture properties at operating temperatures in the range of 2,000° F. in the as cast condition without heat treatment, age hardening and like treatments.