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UNITED STATES PATENT OFFICE

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ALLOY

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2 Claims. (Cl. 75—126)

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The present invention is an alloy and more particularly a forgeable alloy characterized by its good strength at elevated temperatures and a method for heat treating the same.

In selecting materials for such high temperature and high stress applications as steam and gas turbines, it is important to consider all of the characteristics of the material. For example, the wheel of a large propulsion gas turbine because of the conditions under which it operates must be capable of withstanding high stress at both room temperature and elevated temperatures and because of its relatively massive proportions, a material must be selected which can be easily worked. The austenitic steels have been used for this application but are not entirely satisfactory because of their relatively poor strength at room temperatures and because of the difficulty with which they are worked. A more desirable material for such an application would have the better characteristics of the austenitic steels at high temperatures as well as good ambient temperature properties and would be easily worked.

It is, therefore, one of the objects of the present invention to provide an improved forgeable alloy which has good strength characteristics at ambient temperatures and at temperatures up to and including 1150° F.

Another object of the present invention is to provide an improved heat-treatable steel suitable for application to steam and gas turbine parts which is easily forgeable and which has good physical properties at ambient temperatures and good creep and rupture strength up to and including 1150° F.

In carrying out my invention, I employ an alloy which contains 0.1% to 0.4% carbon, 0.1% to 1.5% silicon, 0.2% to 2% manganese, 1% to 5% tungsten, 9% to 18 chromium, 0.1% to 1% vanadium, 1% to 15% cobalt and the balance iron, the combine quantity of these elements totalling 100%. A preferred range of my alloy contains 0.17% to 0.25% carbon, 0.3% to 0.6% silicon, 1% to 1.5% manganese, 2.5% to 3.5% tungsten, 11.5% to 13% chromium, 0.2% to 0.28% vanadium, 4.5% to 5.5% cobalt and the balance iron. A preferred alloy contains 0.25% carbon, 0.4% silicon, 1% manganese, 3% tungsten, 12% chromium, 0.25% vanadium, 5% cobalt and the balance iron.

An alloy of the composition described above containing such ferritic forming elements as chromium, tungsten, vanadium and silicon and such austenitic forming elements as carbon, cobalt and manganese requires a careful balancing of the austenitic and ferritic forming elements so that heating the alloy into the austenitic range causes a complete transformation to austenite. Where the transformation is not complete two phases would exist simultaneously and this condition would be undesirable. The elements of the alloy of my composition are balanced to give optimum high temperature strength with a minimum alloy content in a heat treatable steel. The alloy cost is reduced to a minimum by substituting iron for a part of either or both the manganese and cobalt. However, the same improved characteristics are retained in the alloy with an increase of manganese up to 5% and cobalt up to 15%.

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Since my improved alloy is a heat treatable steel, it is essential that it be heated in the austenitic range so that the alloy may be completely transformed to austenite. Upon cooling, the subsequent transformation produces a hard martensite which may then be tempered and made more ductile.

I have found that the most suitable heat treatment, which is specifically claimed in my divisional application S. N. 39,181 filed July 16, 1948 and assigned to the same assignee as the present invention, includes heating the alloy at about 1100° C. for one to six hours depending upon the thickness or size of the alloy article, cooling it at the natural cooling rate of the article in still air, reheating it at a temperature of about 650° to 670° C. for four to eight hours and again cooling it either in the furnace or in air.

An alloy of my above noted preferred composition which has been heat treated in the manner described has a room temperature tensile strength of 165,900 pounds per square inch and an elastic limit of 75,000 pounds per square inch. It has an elongation of 12% and a reduction in area of 23% while its hardness is about 38 on the Rockwell C scale. Tests at 1,000° F. show a rupture strength of 72,000 pounds per square inch after 100 hours, 66,000 pounds per square inch after 1000 hours, 60,000 pounds per square inch after 10,000 hours. These data extrapolated to 100,000 hours would indicate a rupture strength of 55,000 pounds per square inch. Tests at 1100° F. show a rupture strength of 60,000 pounds per square inch after 100 hours, 44,000 pounds per square inch after 1,000 hours, 31,000 pounds per square inch after 10,000 hours. At this temperature the data extrapolated to 100,000 hours would indicate a rupture stress of 28,000 pounds per square inch.

My improved alloy is further characterized by its metallurgical stability and oxidation resistance up to 1200° F. Specimens made in accordance with my preferred composition described hereinbefore show a thermal expansion rate of .000012 inches/inch/° C. which makes it more suitable than austenitic alloys for use in parts subjected to varying zones of heat. Creep tests at 1000° F. made with specimens of the same composition show a creep rate of 1% per 100,000 hours for a stress of 20,000 pounds per square inch and 0.1% per 100,000 hours for a stress of 14,000 pounds per square inch. My alloy is also machinable and weldable.

While the present alloy is particularly suitable for use in such parts as bolts, rotors, and buckets in steam turbines operating at temperatures up to 1000° F., it may also be employed to advantage in such other steam turbine parts as valves and as wheel material in propulsion gas turbines.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A heat-treatable alloy containing 0.17% to 0.25% carbon, 0.3% to 0.6% silicon, 1% to 1.5% manganese, 11.5% to 13% chromium, 2.5% to 3.5% tungsten, 0.2% to 0.28% vanadium, 4.5% to 5.5% cobalt with the remainder substantially all iron.

2. A heat-treatable alloy containing 0.25% carbon, 0.40% silicon, 1% manganese, 12% chromium, 5% cobalt, 3% tungsten, 0.25% vanadium with the remainder substantially all iron.

EUGENE L. OLCOTT.

REFERENCES CITED

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

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Certificate of Correction

Patent No. 2,462,665. February 22, 1949.

EUGENE L. OLCOTT

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 1, line 40, for "18 chromium" read *18% chromium*; column 2, line 33, for "670° C." read *675° C.*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 30th day of August, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.