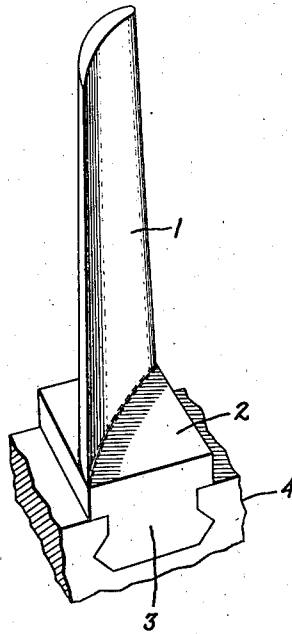


Aug. 14, 1945.

R. H. THIELEMAN
COPPER BEARING STAINLESS STEEL

2,382,273

Filed April 28, 1944



Inventor:
Rudolf H. Thielemann,
by *Harry C. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,382,273

COPPER BEARING STAINLESS STEEL

Rudolf H. Thielemann, Portland, Oreg., assignor
to General Electric Company, a corporation of
New York

Application April 28, 1944, Serial No. 533,163

7 Claims. (Cl. 75—125)

The present invention relates to stainless steel and more particularly to a modified stainless steel alloy containing copper and adapted for use in gas turbines, axial flow compressors, jet propulsion apparatus and the like.

Heretofore the production of satisfactory compressor blades has been one of the serious problems in connection with the manufacture of axial flow compressors for gas turbines and jet propulsion equipment. The number of such blades employed in a compressor depends of course upon the size and capacity of the compressor and may vary from about 500 to 2000 blades, one half of which are stationary and the other half rotary. The shape and dimension of the blades tend to make them very difficult to machine. In cross section the blades have an air foil shape and they are usually twisted about their longitudinal axis. A dovetail structure is provided on one end of the blades so that they may be secured to a supporting member such as a rotary wheel or the like. The length of the blades vary from about one to eight or ten inches while the width may vary from something less than one inch up to about two or three inches depending upon the design. The trailing edge of the blade is very thin and for design reasons it is desirable to make that edge less than .010" thick. Because of the complex shape and thin section, it is desirable to make the blades by the lost wax or precision casting technique commonly employed in the manufacture of dentures and the like.

The single figure of the drawing is a perspective view of a compressor blade and support adapted for use in a gas turbine or jet propulsion apparatus. It comprises a blade 1 having an enlarged end 2 comprising a dovetailed portion 3 whereby the blade may be secured to a suitable supporting member 4.

From a metallurgical point of view the blade material should be at least semi-stainless to resist rusting and corrosion. It should also have a high tensile strength, high elastic limit, good ductility, high fatigue strength, high internal damping capacity, and should be readily ma-

chinalable. A steel having such properties may have the following composition:

Carbon	-----	.12 max.
Chromium	-----	12-14
5 Tungsten	-----	2.5-3.5
Manganese	-----	.50 max.
Nickel	-----	1.8-2.2
Silicon	-----	.50 max.
Phosphorus	-----	.025 max.
10 Sulphur	-----	.025 max.
Iron	-----	Balance

This steel composition is primarily a forging alloy and has desirable properties in the forged and heat treated condition. However, it does not possess good casting properties; for example it has a high melting point, is very sluggish and the thin edged blades can be cast only if the metal is preheated to temperatures of about 150 to 200° F. above its normal casting temperature. When this is done complete blades may be cast but because of the high temperature employed the shrinkage is excessive. Also, the hot shrink causes defects in the castings and the percentage of rejected casting as a result of X-ray examination is very high. It may be stated therefore that it is practically impossible to successfully cast blades having the above noted composition and employing precision casting technique.

30 In carrying out the present invention I employ a modified stainless alloy having the following composition:

Carbon	-----	.10-20
Chromium	-----	12-14
35 Tungsten	-----	2.5-3.5
Manganese	-----	.20-1.00
Silicon	-----	.20-.80
Nickel	-----	1.8-2.2
Copper	-----	.5-3
40 Iron	-----	Balance except for normal impurities.

The preferred composition contains not more than .12% carbon, about 13% chromium, about 3% tungsten, not more than .50% manganese, 45 not more than .50% silicon, 2% nickel and 1%

copper. Phosphorus and sulphur may be present in the alloy but should be kept as low as possible. For example, the alloy preferably should not contain more than .025% phosphorus and not more than .025% sulphur. My improved alloy has desirable fluidity and casting properties and is particularly adapted for use in the precision casting process. One per cent of copper greatly increases the fluidity of the alloy and after a heat treatment at about 700° C. the alloy has unusually high ductility and physical properties. While the useful percentage range of copper employed may vary from .5 to 3% an addition of 1% provides most satisfactory results. Additions above 1.5% produces some precipitation hardening accompanied by a reduction in ductility. The following table represents the physical properties of the alloy in the as-cast condition and after a heat treatment for two hours at 700° C.

Bar No.	Tensile strength, lb/sq. in.	Elongation in 2"	Red. in area per cent
As Cast at Room Temperature			
1.-----	174, 100	1.5	2.6
2.-----	179, 300	1.0	.8
Heat Treated 2 Hrs. @ 700° C.—Air Cooled			
1.-----	131, 200	18.0	51.6
2.-----	133, 700	16.0	45.6
Heat Treated 2 Hrs. @ 700° C.—Furnace Cooled			
1.-----	130, 600	18.0	51.0
2.-----	131, 100	17.0	49.7

After having been heat treated as indicated the cast blades are so ductile that they can be sharply bent 90 or 120° without cracking.

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

1. An alloy containing about .10 to .20% carbon, about 12 to 14% chromium, about 2.5 to 3.5% tungsten, about .20 to 1.00% manganese, .20 to .80% silicon, about 1.8 to 2.2% nickel, about .5 to 3% copper, with the remainder substantially all iron.

2. An alloy containing about 13% chromium, about 3% tungsten, about 2% nickel and about 1% copper and containing fractional percentages but not more than .12% carbon, not more than .50% manganese, not more than .50% silicon, not more than .025% phosphorus, and not more than .025% sulphur, the remainder of the alloy being substantially all iron.

3. An alloy consisting of about .10 to .20% carbon, about 12 to 14% chromium, about 2.5 to 3.5% tungsten, about .20 to 1.00% manganese, about .20 to .80% silicon, about 1.8 to 2.2% nickel, about .5 to 3% copper, the remainder being substantially all iron, said alloy having been heat treated at a temperature of about 700° C. and slowly cooled therefrom.

4. A process for heat treating an alloy consisting of about .10 to .20% carbon, about 12 to 14% chromium, about 2.5 to 3.5% tungsten, about .20 to 1.00% manganese, about .20 to .80% silicon, about 1.8 to 2.2% nickel, about .5 to 3% copper, the remainder being substantially all iron, said process comprising heating the alloy for about two hours at a temperature of about 700° C. and thereafter slowly cooling the alloy.

5. A compressor blade for gas turbines, axial flow compressors, jet propulsion apparatus or the like, said blade comprising an alloy containing .10 to .20% carbon, about 12 to 14% chromium, about 2.5 to 3.5% tungsten, about .20 to 1.00% manganese, about .20 to .80% silicon, about 1.8 to 2.2% nickel, about .5 to 3% copper, the remainder being substantially all iron.

6. A precision casting having the following composition: about .10 to .20% carbon, about 12 to 14% chromium, about 2.5 to 3.5% tungsten, about .20 to 1.00% manganese, about .20 to .80% silicon, about 1.8 to 2.2% nickel, about .5 to 3% copper, the remainder being substantially all iron.

7. A precision cast alloy having the following composition, about .10 to .20% carbon, about 12 to 14% chromium, about 2.5 to 3.5% tungsten, about .20 to 1.00% manganese, about .20 to .80% silicon, about 1.8 to 2.2% nickel, about .5 to 3% copper, the remainder being substantially all iron, said casting having been heat treated at 700° C.

RUDOLF H. THIELEMANN.