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MULTICOMPONENT COLUMBIUM ALLOYS

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No Drawing. Filed Dec. 6, 1960, Ser. No. 73,969
3 Claims. (Cl. 75-174)

The present invention is concerned with certain alloys of columbium. The metal columbium is sometimes called niobium. In particular it is concerned with columbium based multicomponent alloys which have high strength at high temperatures and also a very desirable combination of properties which results in easy fabrication. The alloys of the present invention are particularly suitable for fabrication involving rolling into sheets.

The alloys of the present invention all contain at least 5 metals, namely, columbium, tungsten, tantalum, zirconium and molybdenum.

The columbium alloys of the present invention on a weight basis contain from 9 to 11 percent tungsten, from 5 to 32 percent tantalum, from 0.5 to 2.0 percent molybdenum and from 0.25 to 1.0 percent zirconium, with the balance being columbium. Within the above ranges, alloys are obtained which have high strength at elevated temperatures and outstanding ease of fabrication. Sheets of these alloys may be rolled at unusually low temperatures. They can be rolled into sheets at temperatures below 900° F. and in many cases at temperatures of 500° F. or lower. At the same time, however, the alloys possess the high strength at high temperature which is desirable in columbium based alloys.

Prior to the present invention columbium alloys having comparable high strength at high temperatures required a temperature of at least 1800° F. for rolling into sheets. Rolling at such high temperatures, however, produced rough surfaces, while with the present invention rolling at a low temperature produces a smooth surface and prevents losses due to oxidation. It is, of course, obviously easier and more economical to work at lower temperatures.

The inclusion of tungsten in the alloy increases the strength of the material at high temperatures. In like manner the inclusion of tantalum increases the strength at high temperature. The addition of molybdenum also increases the strength of the alloy as does the addition of zirconium but these two materials do not function in equivalent manner. The function of molybdenum is as a solid solution hardener, while zirconium functions by formation of intermetallic compounds.

Unless the limits of composition expressed above are adhered to, the desirable results are not obtained. For example, if the tungsten content is made too high the material becomes too brittle and cannot be rolled at low temperatures. In similar fashion the inclusion of too much molybdenum or too much zirconium results in an alloy which is too brittle to be rolled at low temperatures. The inclusion of too much tantalum results in an alloy having too high a density to compete with other alloys on the basis of strength to weight ratio.

The fabricability of the alloys of the present invention is improved still further and the crystal size is reduced by incorporating in them a small amount of boron. The

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amount of added boron may vary between 0.01 and 0.3 percent on a weight basis. The preferred amount of boron to be added is from 0.08 percent to 0.2 percent by weight. The optimum weight percent of the added boron is 0.1 percent.

The following examples are given solely for the purpose of illustration and are not to be considered as limitations of the invention, many variations of which will occur to those skilled in the art without departing from the spirit or scope thereof.

Example 1

A mixture was made of finely divided metals having the following composition by weight: 55.9 percent columbium, 30 percent tantalum, 11 percent tungsten, 2 percent molybdenum and 1 percent zirconium. 0.1 percent boron was also included. The mixture was blended and then pressed into a bar for ease of handling. The bar was melted in an electron beam furnace at a vacuum of less than 0.1 micron, and was allowed to solidify as an ingot. The ingot was forged into a plate and the plate was conditioned, i.e., it was machined to remove the oxide film and then stress relieved. The plate was rolled by putting it through a two high mill at a temperature which varied between 300 and 500° F. The resulting 60 mil sheet had the following characteristics: as rolled, the sheet had a tensile strength of 138,000 p.s.i. at room temperature. The sheet was then stress relieved at 2400° F. for one hour, following which it had the following characteristics: tensile strength of 104,500 p.s.i. at room temperature; at 2400° F., tensile strength of 27,000 p.s.i., and a modulus of elasticity of 14.7×10^6 p.s.i. at 2400° F.

Example 2

Numerous other alloys within the ranges discussed above were prepared both with and without from 0.01 to 0.3 percent by weight added boron. In all cases the material had high strength at high temperature along with better fabricability than prior are columbium alloys of comparable strength at high temperatures.

What is claimed is:

1. A columbium alloy consisting essentially of, on a weight basis, from 9 to 11 percent tungsten, from 5 to 32 percent tantalum, from 0.25 to 1.0 percent zirconium, from 0.5 to 2.0 percent molybdenum, and from 0.01 to 0.3 percent boron, with the balance being columbium.

2. A columbium alloy consisting essentially of, on a weight basis, 30 percent tantalum, 11 percent tungsten, 2 percent molybdenum, and from 0.01 to 0.3 percent boron, with the balance being columbium.

3. A columbium alloy consisting essentially of, on a weight basis, 30 percent tantalum, 11 percent tungsten, 2 percent molybdenum, and 0.1 percent boron, with the balance being columbium.

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