

UNITED STATES PATENT OFFICE

2,675,309

TITANIUM BASE ALLOYS WITH ALUMINUM
AND MANGANESE

Milton B. Vordahl, Long Hill, Conn., assignor, by
mesne assignments, to Rem-Cru Titanium,
Inc., Midland, Pa., a corporation of Pennsyl-
vania

No Drawing. Application December 3, 1949,
Serial No. 131,044

6 Claims. (Cl. 75-177)

1

This invention relates to titanium base alloys, and more specifically to a ternary alloy of titanium with aluminum and manganese.

The binary alloys of titanium and aluminum show improved physical properties as compared with titanium itself but the improvement in strength at accepted ductility levels is of moderate proportions, with the result that the structural uses of such alloys are limited. The binary alloys of titanium with up to about 13% manganese show greatly improved strength and particularly in the region of 6% to 13% manganese content a very favorable ratio of strength to ductility. However, the characteristics of these alloys are such that their optimum properties are best developed by a processing associated with rolling or drawing, thus they are useful chiefly in the form of rod, wire or sheet.

The present invention comprises the discovery that the concurrent use of manganese and aluminum in titanium-base alloys is productive of properties which render the alloys more universally useful than either the binary alloy of titanium and aluminum or the binary alloy of titanium and manganese.

An outstanding difficulty in titanium metallurgy is the tendency of titanium and its alloys, when in the liquid phase, to dissolve or combine with refractory container materials, both melting crucibles and casting molds. Carbon crucibles and molds have been quite useful in handling molten titanium and its alloys, but difficulties are too frequently encountered, especially with the alloys rich in manganese, iron or chromium, in that the reaction rate between melt and crucible or mold is increased by the presence of the alloy constituent. Instances have been noted, particularly with manganese alloys, and with the mold preheated for outgassing and to minimize cold shuts (cast shuts), that the melt continues to react with the mold even after removal from the hot zone of the furnace. This has not been encountered with manganese alloys containing at least 1% aluminum, and molds can frequently be re-used a number of times, the wetting and sticking tendency apparently having been reduced considerably. Cleaner and more easily scarfed and machined ingot surfaces result. In addition, there has been shown less tendency toward alloy segregation with the ternary than with the binary alloy.

Excellent results have been secured with alloys containing as little as 2% of aluminum with 2% of manganese, and as little as 1% aluminum with about 7% manganese, balance in each alloy sub-

2

stantially all commercial titanium. While the total alloy metal content may be as high as 10%, a total of about 8% is preferred, this alloy content being divided between manganese and aluminum in proportions varying from about 1% aluminum and 7% manganese to about 6% aluminum and 2% manganese.

Typical alloys and their properties in the warm rolled and stabilized condition are as follows:

Composition (Balance Titanium)	Vickers Hardness	0.2% Offset	Ultimate	Elongation in 1/2"	Bend Radius T
7Mn 1Al	201	51,000	76,000	21	0.8
6Mn 2Al	319	132,200	143,500	17	2.2
5Mn 3Al	340	148,500	161,000	16	3.0
4Mn 4Al	345	142,000	163,500	13	3.4
3Mn 5Al	336	154,500	166,800	12	5
2Mn 6Al	349	162,100	176,400	10	4.8
	353	165,400	176,200	9	5.8

It is in the as-forged condition that the alloys of this invention exhibit the most distinctive properties as compared with other titanium-base alloys, particularly binary titanium-manganese alloys. For example, an alloy containing 5% aluminum and 2% manganese, balance substantially all commercial titanium, forged at a temperature of 1650° F., shows a yield strength of 140,000 p. s. i. and an elongation of 21%. An alloy of 4% aluminum and 4% manganese, balance substantially all commercial titanium, rough forged at 1600° F., and finish forged at 1500° F., has a yield strength of 147,000 p. s. i., and an elongation of 18%—an extraordinary combination of strength and ductility as compared with forgings of the binary analogues. These alloys thus have a universal adaptability which is lacking in other titanium-base alloys, being highly useful both as forgings and as rolled sheet or drawn wire. In sheet, some truly extraordinary properties have been secured. An alloy containing 3.94 manganese, 5.54 aluminum, balance commercial titanium, rolled at 650° C., annealed for 16 hours at 550° C., cold-rolled 10%, and stress-relieved for one hour at 400° C., showed a yield strength of over 190,000 p. s. i., an ultimate strength of about 220,000 p. s. i., an elongation in 1/2" of 5%, and a cross-bend ductility of 4.3T. (Bend ductility is measured as the radius to which the specimen can be bent at an angle of 75° without cracking, the radius being expressed as a multiple of the specimen thickness.)

The alloys of this invention are susceptible to embrittlement by an excess of carbon or nitrogen.

3

While the quantities of carbon, oxygen and nitrogen normally present in high quality commercial titanium can be tolerated, the nitrogen content should not exceed about 0.1% and the carbon content should not exceed about 0.25%.

What is claimed is:

1. A titanium base alloy consisting essentially of 1 to 7% manganese, 2 to 6% aluminum, up to 0.25% carbon, balance titanium, and characterized in being ductile and forgeable and in having a tensile strength substantially in excess of the unalloyed titanium base metal.

2. A titanium base alloy consisting essentially of 2 to 7% manganese, 1 to 6% aluminum, up to 0.25% carbon, balance titanium, and characterized in being ductile and forgeable and in having a tensile strength substantially in excess of the unalloyed titanium base metal.

3. An alloy consisting of about: 1 to 7% manganese, 2 to 6% aluminum, up to 0.25% carbon, up to 0.1% nitrogen, balance titanium.

4

4. An alloy consisting of about: 2 to 7% manganese, 1 to 6% aluminum, up to 0.25% carbon, up to 0.1% nitrogen, balance titanium.

5. An alloy consisting of about: 1 to 7% manganese, 2 to 6% aluminum, balance titanium.

6. An alloy consisting of about: 2 to 7% manganese, 1 to 6% aluminum, balance titanium.

References Cited in the file of this patent

10 Zeitschrift für Metallkunde, vol. 29 (1937), page 190.

15 Titanium Project—Navy Dept., Bureau of Aeronautics—Navy Contract No. NOa(s) 8698, "The Manufacture of Ductile Titanium and Titanium Alloys," Report No. 14, pages 6 and 7 (May 11, 1948), Final Report No. 17, pages 151-155 (Sept. 1, 1948).

Metallurgia, April 1949, page 304.

Product Engineering, November 1949, page 149.

20