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MACHINABLE TITANIUM BASE TELLURIUM ALLOY

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This invention relates to titanium-base alloys and, more particularly, to titanium-base alloys characterized by good machining properties.

In the past, little has been known concerning the machinability of titanium metal and, consequently, there is practically no information relative to machinable alloys of titanium. Separate publications have compared the machinability of titanium to that of stainless steel, in one instance, and to that of free-machining stainless steel in another instance. Since the machinability of stainless steel and free-machining stainless steel differ by a factor of about two, it will be apparent that the actual machinability of titanium metal is a somewhat controversial subject. In view of recent interest in titanium alloys and their applications, it has become increasingly desirable that information relative to the machinability of titanium alloys be obtained and that titanium alloys having good machining properties be developed.

It is, therefore, an object of this invention to provide alloys of titanium which are readily machinable.

It is a further object of this invention to provide free-machining alloys of titanium comprising titanium and an element having low solubility in titanium.

Yet another object of this invention is to provide free-machining alloys comprising titanium and tellurium.

Other objects and advantages of this invention will be apparent, in view of the following detailed description thereof:

In general, this invention relates to free-machining titanium-base alloys comprising titanium, and from about 0.02% to about 0.45% tellurium, particularly alloys containing from 0.05% to 0.40% tellurium.

The introduction of tellurium as an alloying element in titanium presents substantial difficulty because of the low boiling point and high vapor pressure of tellurium. For this reason, it is desirable to form a master alloy of titanium and tellurium to provide a relatively high-boiling point compound for subsequent addition to the melts used in preparing the alloys of this invention. The master alloys are readily obtained by a process wherein tellurium powder is mixed with fines from crushed titanium sponge and the resulting mixture encapsulated in Vycor glass under partial pressure of argon, and then subjected to controlled heating. In the temperature range of from 950° F. to 1000° F., the tellurium reacts exothermally with the titanium, producing compounds having a metallic appearance. These compounds, or master alloys, may then be used in preparing titanium-tellurium alloys of any desired composition.

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Ti-Te alloys of the present invention have been prepared and evaluated for machinability with results as tabulated in Table I below. Two common types of machining operations have been used in evaluating the machining properties of the present alloys. These two operations, turning on a lathe and cutting with a saw, are believed to be representative machining operations and to afford a reasonable evaluation of relative machinability. Data reported in Table I are reported on the basis of the machinability of unalloyed titanium as a reference. A value of 100 has arbitrarily been assigned as the machinability index of unalloyed titanium. Alloys which cut faster, or which have heavier feeds, have an index rating greater than 100. The exact index value is conveniently computed from observed values obtained during lathe tests. For example, the lathe-test index may be computed from the average feed by an equation, as follows:

$$\text{Index} = 100 \times \frac{\text{Avg. feed on alloy}}{\text{Avg. feed on standard}}$$

Table I

Composition,[1] Percent Te	Lathe Test Index	Saw Test Index
Unalloyed	100	100
0.07	106	98
0.16	104	97
0.27	105	104
0.47	94	81

[1] Balance titanium.

Lathe tests reported above were made on a special type lathe provided with elements for applying a predetermined thrust force to the cutting tool and for measuring the resultant feed. Other conditions being constant, a metal with superior machinability cuts faster (has a heavier feed) in this test. The lathe tests reported above were run at 120 lbs. thrust and 27 ft. per minute testing speed. Saw tests were made on an 11 ft.-6 in. band saw, travelling at 46 ft./min., and having ¾-in. wide blade with 10 teeth per inch.

The increased machinability obtained by alloying titanium with tellurium is gained without attendant loss of mechanical properties. Table II below shows that mechanical proper-

ties are generally improved by the tellurium additions of this invention:

Table II

Composition,[1] Percent Te	Ultimate Tensile Strength, p. s. i.	0.2 Percent Yield Strength, p. s. i.	Elongation, Percent in 1-inch	Reduction of Area, Percent	Vickers Hardness Number
Unalloyed	75,400	54,300	29	51	183
0.07	80,600	66,000	30	55	201
0.16	83,200	64,000	29	45	204
0.27	79,200	60,000	27	45	190
0.47	78,600	54,500	28	44	203

[1] Balance essentially all titanium.

From Table II it is clear that the alloys of this invention possess increased tensile strength and yield strength, as compared with unalloyed titanium, and retain excellent ductility properties without sacrifice of hardness.

It will be clear that useful alloys with increased properties of machinability and good machinability and good mechanical properties have been disclosed herein. It will be understood that the particular properties and descriptions are not intended to limit the scope of the invention but are presented for illustrative purposes only. The titanium used in preparing the alloys of the present invention may be produced by either the magnesium-reduction method or by the iodide process, or in any other way, and may contain small amounts of impurities, such as carbon, iron, and nitrogen.

What is claimed is:

1. A titanium-base alloy consisting essentially of from .02% to .45% tellurium, balance titanium, characterized by an improved machinability of at least 104 as determined by a lathe test as compared with 100 for an unalloyed titanium specimen.

2. A titanium-base alloy consisting essentially of from .05% to .40% tellurium, balance titanium, characterized by an improved machinability of at least 104 as determined by a lathe test as compared with 100 for an unalloyed titanium specimen.

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References Cited in the file of this patent

Goldhoff, R. M., et al.: "The Influence of Insoluble Phases on Machinability of Titanium," published as ASM Preprint #30, 1952.