United States Patent Office

3,264,147

Patented August 2, 1966

3,264,147

BERYLLIUM ALLOY AND PROCESS

William Bonfield, St. Louis Park, and Jack A. Sartell, Hopkins, Minn., assignors to Honeywell Inc., a corporation of Delaware

No Drawing. Filed Oct. 16, 1963, Ser. No. 316,516
7 Claims. (Cl. 148—126)

This invention relates to alloys composed predominately of beryllium. More particularly, it has to do with a beryllium alloy containing relatively small amounts of silver and a precipitation hardening process for preparing the same.

Materials used in precision instruments, such as gyroscopes and accelerometers, can be seriously impaired by dimensional changes in the constituent materials. The materials used in such devices must perform under load in an entirely predictable manner and must return to the original zero-point on removal of the stress. In other words, deformation must be both isotropic and elastic in nature.

Beryllium, due primarily to its low density, has come into wide use in the industry as the basic material for these precision instruments. Hot pressed beryllium because of its exertmely fine grain-structure behaves isotropically; but, unfortunately, begins to undergo microscopic amounts of plastic deformation at low stress levels.

Ordinarily, 0.2% plastic strain is accepted as the point beyond which plastic strain is of engineering importance. The stress required to produce 0.2% plastic strain is therefore called the "engineering yield stress" hereinafter referred to as EYS. Since much smaller dimensional changes can be damaging to the performance of a precision instrument, such as an inertial guidance device, a more precise criterion for yielding is required. The smallest strain which can be readily detected by devices presently available, such as optical or electrical resistance strain gages, is 2×10^{-6} inches/inch; therefore, a new term for minute plastic strain has come into use. This term is "microscopic yield stress" hereinafter referred to as MYS, and is defined as that stress which is necessary to produce a plastic strain of 2×10^{-6} inches/inch. It is important to realize that a wide gap exists between the EYS and the MYS in materials such as beryllium. For hot-pressed beryllium the EYS is 30–35,000 p.s.i. while its MYS is about 2,600 p.s.i. This extremely low value of MYS limits, for example, the speed of rotation of a gyroscope and further limits the effective use of beryllium in other precision instruments of this general type.

Accordingly, it is an object of this invention to provide beryllium alloys possessing high MYS.

Another object is to provide a process for preparing beryllium-silver alloys possessing high MYS.

A further object is to provide a precipitation hardened beryllium silver alloy.

Another object is to provide a precipitation hardening process for beryllium in which silver is the precipitation hardener.

It has been discovered in the alloying of silver with beryllium that a pronounced low temperature aging reaction exists. Utilizing this effect it is possible to increase the MYS of the alloyed material threefold.

Alloys of beryllium containing 1–8% silver exhibiting the advantages of the present invention have been prepared by powder metallurgy techniques. Due to the fact that the beryllium must exhibit isotropic properties and an essentially void free structure, only powder techniques have been found successful in the preparation of this material.

For example, a series of alloys of beryllium with 1% to 8% silver by weight were prepared in the following

manner. The component powders were mixed in a ball mill for 24 hours then hot pressed in a vacuum for 1 hour at 865° C. under a pressure of 13,000 p.s.i. This process of preparing the alloy, although preferred, is not necessarily limited to the specific parameters listed. By increasing temperature, the pressure can be lowered; by increasing time of hot pressing, the temperature can be lowered and so on.

The particularly unique feature regarding this group of alloys is an aging treatment which is employed to give substantial increases in MYS. The alloys after preparation are annealed for about 2 hours at 1000° C., cooled, then reheated to about 300° C. and aged about 4 hours. This low temperature aging treatment results in precipitation hardening of the alloy. In other words, the silver constituent forms a solid solution with some of the beryllium upon annealing. During the aging process, a silver-rich phase precipitates in particle form along the beryllium grain boundaries and within the grains themselves. The results obtained are shown in the table and compared with samples (A and B) of typical commercial beryllium. It can be seen that samples, which are annealed only, have significantly different values of MYS than the samples which have been annealed and aged in accordance with the invention. Further, it can be seen that the alloys treated in accordance with the invention have an improved MYS when compared to the pure beryllium samples A and B which have been treated with the same process.

Table

Material	Anneal (1,000° C./2 Hrs.) MYS (p.s.i.)	Annealed and aged NYS (p.s.i.)
Commercial A	3,000	3,000
Commercial B	3,000	3,000
Be 1% Ag	6,100	16,600
	5,500	15,800
	6,500	16,600
		13,700
Average Values	6,000	14,200
Be 8% Ag	9,700	12,100
	7,400	17,000
	8,700	12,600
	7,400	
Average Values	8,300	13,900

As to the 1 to 8% limits placed on the silver with the beryllium, when appreciably greater than 8% silver is utilized, the density of the alloy becomes high enough to be detrimental for a material used in some precision instruments. Also, the amount of silver present gives rise to melting problems since at percentages appreciably greater than 8% silver the excess silver tends to melt at annealing temperatures and destroy the desirable crystal structure of the alloy.

The lower limit of 1% is not fixed and it is indeed possible to prepare an alloy in accordance with this invention in which the amount of silver is as low as 0.5% by weight. However, in the range below 1% silver, the mechanical properties vary widely with slight changes in percentage composition and extremely delicate control is required to prepare a satisfactory alloy. Hence, the preferred embodiments of this invention contain at least about 1% silver to insure a useful alloy exhibiting not only high MYS but high mechanical strength.

What is claimed is:

1. A precipitation hardened alloy characterized by a high microscopic yield stress containing from about 1% to about 8% silver by weight, balance beryllium.

2. A precipitation hardened alloy characterized by an average microscopic yield stress of about 14,000 p.s.i.

containing from about 1% to about 8% silver by weight, balance beryllium.

3. The method of preparing a beryllium-silver alloy exhibiting improved microscopic yield stress comprising: mixing finely divided silver and beryllium powders, the composition being from about 1% to about 8% silver, balance beryllium; hot pressing the mixture for at least one hour at a temperature of about 865° C. and a pressure of about 13,000 p.s.i. to form an alloy; annealing said alloy for about two hours at a temperature of about 1000° C.; cooling said alloy; and low temperature aging said alloy for about four hours at a temperature of about 300° C.

4. The method of preparing a beryllium-silver alloy exhibiting improved microscopic yield stress comprising: mixing silver and beryllium powders, the composition being from about 1% to about 8% silver, balance beryllium; hot pressing said mixture to form an alloy; annealing said alloy for about two hours at a temperature of about 1000° C.; cooling said alloy; and low temperature aging said alloy for about four hours at a temperature of about 300° C.

5. The method of preparing a beryllium-silver alloy exhibiting improved microscopic yield stress comprising: mixing silver and beryllium powders, the composition beng from about 1% to about 8% silver, balance beryllium; hot pressing said mixture to form an alloy; annealing said alloy for about two hours at a temperature of about 1000° C.; cooling said alloy; and low temperature aging said alloy for about four hours at a temperature of about 300° C.

6. The method of preparing a beryllium-silver alloy exhibiting improved microscopic yield stress comprising: mixing finely divided silver and beryllium powders, the composition being greater than zero percent and less than about 8% silver, balance beryllium; hot pressing said mixture to form an alloy; annealing said alloy for about two hours at a temperature of about 1000° C.; cooling said alloy; and low temperature aging said alloy at a temperature of about 300° C.

7. The alloy according to claim 1 wherein the silver content is greater than zero percent and less than about 8%.

References Cited by the Examiner

Hansen: Constitution of Binary Alloys, McGraw-Hill Co., Inc., New York, 1958, pages 9 and 10.

LMSD–288140, Technical Report, vol. II, Lockheed Aircraft Corp., California, January 1960, relied on Section 7, pages 1–2 and 1–3 and 3–5.

DAVID L. RECK, *Primary Examiner.*

C. N. LOVELL, *Examiner.*