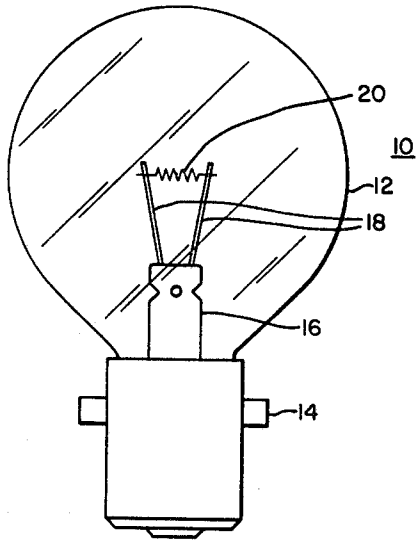
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TUNGSTEN-BASE ALLOY AND FILAMENT

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WITNESSES

Theodore F. Wrobel

James F. Young

INVENTOR

Ronald C. Koo

BY W. D. Palmer

ATTORNEY

United States Patent Office

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TUNGSTEN-BASE ALLOY AND FILAMENT

Ronald C. Koo, East Orange, N.J., assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

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ABSTRACT OF THE DISCLOSURE

Tungsten-base alloy includes rhenium or osmium or mixtures thereof in solid solution as well as finely divided, dispersed particles of zirconium or hafnium borides or nitrides or mixtures thereof. The alloy, which can be used as an incandescible filament, displays high strength at high temperatures and reasonably good ductility at low temperatures.

Background of the invention

This invention relates to tungsten-base alloys and, more particularly, to such alloys which have high strength at high temperatures for use as incandescible filaments or tungsten structural or support members.

Tungsten-base alloys which comprise solid solutions with other metals, such as rhenium or osmium, are known. Such solid solution alloys display little if any improvement in strength at high temperatures as compared to tungsten per se. Apparently this is due to the fact that the dislocations, which necessarily accompany plastic deformation, are relatively free to glide, as in a pure metal.

Dispersed second-phase tungsten alloys are also known, and so-called thoriated tungsten is an example wherein small particles of thorium dioxide are dispersed throughout the tungsten. This increases the strength of the tungsten alloy since the paths of glide of dislocations must traverse the dispersed second-phase particles. The increase in strength in such alloys is not as good as desired, however, since the dislocations can follow a screw-like path in order to avoid the dispersed second-phase particles.

Summary

It is the general object of this invention to provide a tungsten alloy which displays high strength at high temperatures.

It is another object of this invention to provide a tungsten alloy which displays high strength at high temperatures and reasonably good ductility at low temperatures.

It is an additional object to provide a tungsten alloy which is formed as an incandescible filament having good high-temperature strength characteristics and reasonably good ductility at low temperatures.

The foregoing objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by providing a tungsten-base alloy which comprises a solid solution of tungsten plus rhenium, or osmium, or mixtures thereof, wherein the weight ratio of rhenium to tungsten is from 2% to 10%, the weight ratio of osmium to tungsten is from 3% to 30%, and the weight ratio of total rhenium plus osmium to tungsten is from 2% to 30%. Dispersed throughout the solid solution are finely divided particles of zirchonium borides or nitrides, or hafnium borides or nitrides, or any mixtures thereof, with the volume ratio of the dispersed particles to the solid solution being from ½% to 5%.

Brief description of the drawing

For a better understanding of the invention, reference should be had to the drawing wherein the sole figure is an elevational view of an incandescent lamp which incorporates a filament fabricated from the present alloy.

Description of the preferred embodiments

There is shown in the sole figure an incandescent lamp **10** comprising a light-transmitting envelope **12** having a base **14** secured to the neck thereof. A conventional reentrant stem-press **16** is affixed within the bulb and has the lead-in conductors **18** sealed therethrough. The incandescent filament **20**, which is formed from the present alloy, is supported between the inwardly extending extremities of the lead-in conductors **18**. Particularly in the case of a miniature lamp, a butt-seal construction could also be used.

The present alloy comprises a solid solution of tungsten plus rhenium, or osmium, or mixtures thereof, wherein the weight ratio of rhenium to tungsten is from 2% to 10%, the weight ratio of osmium to tungsten is from 3% to 30%, and the weight ratio of total rhenium plus osmium to tungsten is from 2% to 30%. Dispersed throughout the solid solution are finely divided particles of zirconium borides or nitrides, or hafnium borides or nitrides, or any mixtures thereof. The volume ratio of the particles to the solid solution is from ½% to 5%. Preferably the weight ratio of rhenium to tungsten is from 5% to 8%, the weight ratio of osmium to tungsten is from 5% to 15% and the weight ratio of rhenium plus osmium to tungsten is from 5% to 15%. Preferably the volume ratio of dispersed second-phase particles to the solid solution is from 2% to 3%.

The preferred method for forming the present alloy, and achieving the proper dispersion of the second-phase particles, is a milling, compaction, self-resistance-sintering procedure. The tungsten in finely divided form has added thereto finely divided rhenium, or osmium, or mixtures thereof, with the weight ratio of the rhenum or osmium to tungsten corresponding to that ratio desired in the solid solution. To these components are added finely divided particles of zirconium borides or nitrides, or hafnium borides or nitrides, or any mixtures thereof, with the amount of boride or nitride addition calculated with respect to the final desired volume percent of these particles in the solid solution. More specifically, tungsten powder has added thereto 6% by weight of finely divided rhenium or 8% by weight of finely divided osmium. To this mixture is added 2% by volume of any of the indicated borides or nitrides, with the volume percent calculated on the basis of a 100% theoretical density for each of the constituents. The mixture is then ball-milled for a prolonged period, such as twenty-four hours, in order to reduce the size of the particles and to insure a complete dispersion of all constituents of the alloy. The state of division of the particles as initially added to the ball-mill is not critical and as an example, the average particle size of all constituents, as initially mixed, is slightly less than about 10 microns.

After milling as described, the resulting mixture is pressure formed into a compact, the compact presintered by heating it in a hydrogen atmosphere at a temperature of approximately 1000° C. for approximately 30 minutes, and the resulting compact thereafter self-resistance-sintered in a hydrogen atmosphere, with the ultimate sintering temperature being just slightly below the fusion temperature of the compact. As an example, the compact is heated during sintering to a final temperature of approximately 95% of that temperature required to fuse the compact, and this maximum sintering temperature is maintained for approximately thirty minutes. Thereafter, the compact is swaged and drawn or rolled, in order to achieve the final desired shape. In the case of filament formation, a conventional swaging and drawing technique is utilized.

From a theoretical standpoint, it appears that the crystal lattice imperfections which exist in the tungsten-osmium or tungsten-rhenium solid solution more closely approach the partial dislocations which are present in a face-centered-cubic metal, as compared to the aligned type of dislocations which exist in a body-centered-cubic metal, as typified by tungsten per se. When the dispersed second-phase impurities, such as the indicated borides or nitrides, are included in the solid solution, the partial dislocations in the solid solution require that the path of dislocations which is encountered during plastic deformation generally follow a predetermined plane, as opposed to the more linear path of dislocations which will normally occur in tungsten per se. These partial dislocations which are present in the solid solutions thus make it much more difficult for the glide of dislocations to avoid the obstacles to their path presented by the dispersed second-phase particles. The result is that the high-temperature strength of the alloy is greatly increased.

The state of division of the dispersed second-phase particles in the final metal is not particularly critical, although as a general rule, the more finely divided these particles, the more effective they are in improving the strength of the material. For a milling period as specified hereinbefore, the finely divided borides or nitrides will have a state of division in the order of 0.1 to 0.2 micron.

The present metal is extremely strong up to temperatures of at least about 2200° C. This makes it very useful for some types of lamp filaments, such as miniature lamps, which operate at a relatively low temperature. In addition, the present tungsten-base alloy displays sufficiently good ductility at relatively low temperatures to enable it to be worked into desired shapes. The present tungsten-base alloy also has use as tungsten structural or support members wherein high temperature strength is a requirement.

It will be recognized that the objects of the invention have been achieved by providing a tungsten-base alloy which has high strength at high temperatures as well as a reasonably good ductility at low temperatures and this alloy has particular use as an incandescible filament.

While the preferred embodiments have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

What is claimed is:

1. A tungsten alloy which displays high strength at high temperatures, said alloy comprising:

(a) a solid solution of tungsten plus rhenium, or osmium, or mixtures thereof, wherein the weight ratio of rhenium to tungsten is from 2% to 10%, the weight ratio of osmium to tungsten is from 3% to 30%, and the weight ratio of total rhenium plus osmium to tungsten is from 2% to 30%; and

(b) finely divided particles of zirconium borides or nitrides, or hafnium borides or nitrides, or any mixtures thereof dispersed throughout said solid solution, wherein the volume ratio of said particles to said solid solution is from ½% to 5%.

2. The alloy as specified in claim **1**, wherein said alloy is formed into a member having the configuration of a lamp filament.

3. The alloy as specified in claim **1**, wherein said weight ratio of rhenium to tungsten is from 5% to 8%, said weight ratio of osmium to tungsten is from 5% to 15%, said weight ratio of rhenium plus osmium to tungsten is from 5% to 15% and said volume ratio of said particles to said solid solution is from 2% to 3%.

4. The alloy as specified in claim **3**, wherein said alloy is formed into a member having the configuration of a lamp filament.

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JOHN W. HUCKERT, *Primary Examiner.*

A. J. JAMES, *Assistant Examiner.*

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