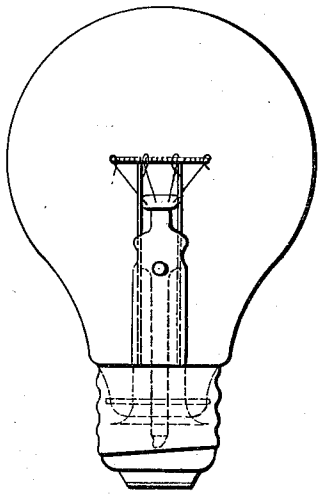
July 9, 1929. J. H. RAMAGE 1,720,000

VIBRATION AND SAG RESISTANT FILAMENT

Filed July 28, 1926



INVENTOR
John H. Ramage.
BY
ATTORNEY

Patented July 9, 1929. 1,720,000

UNITED STATES PATENT OFFICE.

JOHN HUMPHREYS RAMAGE, OF BLOOMFIELD, NEW JERSEY, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA.

VIBRATION AND SAG RESISTANT FILAMENT.

Application filed July 28, 1926. Serial No. 125,568.

This invention relates to filaments for incandescent lamps and more particularly to filaments that are resistant to sag and offsetting when used in a coil type of lamp which is burned subject to vibration.

Non-sag filaments of the character at present employed in the manufacture of certain types of incandescent lamps, when burned under vibratory or shock conditions, deteriorate very rapidly to a weakened offset crystal structure, the life of the lamp being shortened in direct proportion to the intensity and also the frequency of the vibration. By non-sag wire is meant a substantially pure tungsten wire having a large interlocking crystal structure.

A study of the crystal structure during the burning of a filament indicates that a straight-sided "offset favorable" structure develops which is apparently occasioned by the repeated shocks, so that the interlocking or mortised grain structure favorable to strong offset resisting non-sag wire is lost early in the useful life of the lamp. A structure of the straight-side character is susceptible to offsetting if the wire is burned continuously but an even more serious trouble is the inherent weakness of such a structure when cold as it has been found that many failures occur when the filament is in such condition. Apparently, therefore, the straight-sided crystal structure materially weakens the filament not only from the standpoint that an offset crystal structure is readily promoted when the filament is hot, but also because a filament of this character is structurally weak when cold and is easily broken when subjected to shock.

It is apparent that although a tungsten filament of the non-sag type is capable of resisting sag it is inherently weak when subjected to shock and vibration.

A further study of filaments of the thoriated-tungsten type, ordinarily termed offset-resisting filaments shows that such a filament resists structural changes even under severe vibration. However, such a filament has a crystal structure which is especially susceptible to sag, since the wire is composed of crystals or grain which have a flat or straight-sided shape. These grains readily slip on each other and it is only by reason of the great number of them that offsetting while hot and weakness to shock while cold is prevented. The perceptible sag of such a filament is the accumulation of many of these infinitesimal intergranular slips all in the same direction.

It is apparent from the foregoing that a thoriadoped tungsten filament, although capable of resisting vibration and shock, is not adaptable for resisting sag.

From the foregoing I have concluded that the ideal filament wire for resisting structural changes of any sort is one which combines certain of the desirable properties imparted to the filament for rendering the same resistant to sag and certain of those properties which make the filament resistant to offsetting. More specifically stated, an ideal filament according to my invention is one which is composed of a large grained interlocking structure, characteristic of non-sag wire, and which has a highly refractory doping material disposed between the crystals, which prevents or retards the boundary straightening action that takes place in the regular non-sag wire.

In view of the foregoing it is an object of my invention to provide a method of producing a filament for incandescent lamps which is resistant to internal structural alterations such as result in sagging, offsetting and failure through vibration or shock.

A further object of the invention is the provision of a filament capable of resisting vibration and which is also resistant to sag and offsetting.

A more specific object of my invention is to provide a method of producing a filament composed of tungsten composed of large interlocking crystals and having disposed between the grain boundaries a highly refractory doping material capable of preventing or retarding the formation of crystals having a straight-sided or flat shape.

A still more specific object of my invention is to provide a filament composed of tungsten composed of large interlocking crystals having tantalum oxide or other highly refractory doping material disposed between the grains thereof.

Other objects of the invention will become apparent as the following description is read when taken in connection with the accompanying drawing in which the single figure illustrates a conventional form of incandescent electric lamp containing a filament of the character forming the subject of my invention.

Various methods may be employed for obtaining the result forming the subject of my invention, it being understood that the important features thereof reside in providing a filament possessing non-sag, non-offset and vibration-resistant properties.

I will now give a specific example of my invention as applied to the production of a filament of the character specified heretofore.

A slug or filament of a metal alloy is first formed, such slug or filament consisting of a tungsten-tantalum alloy made in accordance with the process described and claimed in my copending application Serial No. 646,266, filed June 18, 1923, and assigned to the same assignee as the present application.

The specific embodiment described in said application consists in preparing a solution of potassium tungstate by dissolving 475 grams of purified tungstic oxide in a boiling solution of potassium hydroxide made by dissolving 275 grams of potassium hydroxide in 1100 cc. of water. A second solution of potassium tantalate is prepared by fusing 10 grams of tantalum oxide in potassium hydroxide, dissolving the compound out with water and filtering. The tantalate and tungsten solutions are added together in proportions dependent upon the amount of tantalum desired in the final product. The mixed solutions are then heated to the boiling point and hot concentrated hydrochloric acid containing about 5% of nitric acid is added in about 10% excess of the amount found necessary to neutralize any excess of potassium hydroxide and to precipitate the dissolved tantalum and tungsten oxides. The precipitate is thoroughly washed, dried, ignited and finally powdered to pass through a 200 mesh screen.

The oxide mixture may then be subjected to any of the usual tungsten oxide reduction processes, such as that described in Coolidge Patent 1,082,933, granted Dec. 30, 1913, which results in the formation of an intimate and homogeneous mixture of powdered metallic tungsten with powdered tantalum oxide. To the mixture so prepared is added from 0.2% to 0.4% of carbon (in the form of lamp black) depending upon the amount of tantalum oxide present, although an excess of carbon may be employed. This material is molded under pressure into slugs of suitable proportion for treating. The treating may be accomplished in any well known manner such as that described in the Coolidge patent mentioned above. After treating, which may also include the step of sintering the metal, the slug of sintered metal alloy may be mechanically worked to any desired form, such as filament wire. As an alternative the oxide mixture may be reduced in illuminating gas or other carbon containing gas, that is to say, the mixture of tungsten oxide and tantalum oxide may be reduced in one step to a mixture of metals by means of carbon containing gases instead of employing hydrogen and mixed carbon to affect the reduction in separate stages as set forth more specifically above.

The above process when carefully followed, results in the formation of a solid solution alloy of tantalum in tungsten which when formed into a filament possesses non-sag properties. A filament of this character, however, is not suitable for resisting vibration for the reason previously mentioned.

In order to render a filament or slug formed of a solid solution alloy of tantalum in tungsten resistant to vibration, I propose to subject the intimately mixed tantalum to oxidizing influences so as to form tantalum oxide between the crystal boundaries of the tungsten. This may be accomplished in accordance with my invention by subjecting the sintered slug to an additional heat treatment in moist hydrogen. This treatment may be readily practiced in any well known sintering furnace. The heat treatment should be continued until substantially all of the tantalum has been oxidized. Since the heating is done in hydrogen, the tungsten will not be materially affected, since tungsten oxide is readily reduced by hydrogen, whereas the tantalum oxide is not.

No specific directions are given with respect to the duration, temperatures, etc., employed in the heat treatment in moist hydrogen since these conditions vary with different quantities of the constituent ingredients, size of slug, etc.

It may also be desirable to convert the tantalum to oxide after a filament of the solid solution alloy of tantalum in tungsten is mounted in a lamp. In such a case, the lamp may be sealed from the air while still containing a slight amount of residual gas. Upon glowing the filament in the presence of this gas the tantalum will combine with the same, and, if such gas is oxygen, the tantalum will be converted to oxide. It is thus apparent that in addition to the formation of a vibration resistant filament, the residual gases in the lamp are simultaneously cleaned up.

The filament formed by practicing my invention consists of substantially pure tungsten having a grain or crystal structure which renders the same resistant to sag and in addition, there is interposed between the crystals, tantalum oxide which serves not only to prevent offsetting of the filament, but also prevents or retards the formation of straight-sided or flat-shaped crystals, thus effectively rendering the filament resistant to vibration.

In place of tantalum any other suitable refractory metal may be employed, it being a condition, however, that the oxide of the metal be stable at the burning temperature of a lamp having such a filament. Furthermore, it is desirable that the added metal be of such a character that it readily combines

with oxygen, and the like, thus enabling the additional function to be obtained of employing the metal as a clean-up agent. For example, a tungsten-thorium mixture may be produced in accordance with the process described in my copending application, Serial No. 125,333, filed July 26, 1926, the reduction of the oxides of both these metals being affected in one step by means of carbon or first by subjecting the mixture of oxides to hydrogen to reduce the tungsten oxide and then to carbon containing gases to bring about the reduction of thoria. The resultant mixture of tungsten and thoria powder may then be pressed, sintered and then subjected to moist hydrogen treatment or the sintered metals mechanically worked to wire form and then placed in a lamp and heated in the presence of the lamp atmosphere with no getter present, the thorium being converted to thorium oxide and thus serving to clean-up the residual gas in the lamp bulb at the same time the desired oxide inclusions between the grains are obtained.

In converting the tantalum to oxide, it may be desirable to accomplish this during the working of the slug into wire form.

Modifications of the invention may suggest themselves to those skilled in the art, but all such modifications are contemplated by me which come within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. The method of manufacturing non-sag, non-offset, and vibration resistant filament wire which comprises forming an intimate mixture of a refractory metal and a metal whose oxide is stable and converting the last mentioned metal to oxide.

2. The method of manufacturing a wire resistant to internal alterations which manifest themselves in sagging, offsetting, etc., which comprises forming a solid solution alloy of refractory metal alloys, one of said metals having an oxide stable at elevated temperatures, and converting the last mentioned metal to oxide.

3. The method of forming a filament free from sagging and offsetting and which is resistant to shock and vibration which comprises heating a solid solution alloy of tungsten and tantalum under oxidizing conditions to convert the tantalum to tantalum oxide, and thereafter forming a filament from the resultant product.

4. The method of forming a metallic product resistant to vibration, offsetting and sagging which comprises intimately mixing a refractory metal whose oxide is irreducible in hydrogen with a metal whose oxide is reducible in hydrogen, sintering said metals to form a coherent mass of metal, and then heating said mass in moist hydrogen to convert the first mentioned metal to oxide.

5. The method of forming a filament resistant to vibration, offsetting and sagging which comprises forming a metal alloy consisting of tungsten and a refractory metal whose oxide is irreducible in hydrogen, mechanically working the alloy to filamentary form and then converting the refractory metal to oxide.

6. The method of forming a filament resistant to vibration, offsetting and sagging which comprises heating a slug composed of an alloy of tungsten and tantalum under oxidizing conditions and thereafter reducing the slug by mechanical working to filamentary form.

7. The method of forming filaments resistant to sagging, offsetting and vibration which comprises heat-treating a compressed body consisting of a small amount of tantalum intimately mixed with tungsten to form a solid solution of tantalum in tungsten, then heating the sintered body in moist hydrogen and thereafter working the sintered body to filamentary form.

8. The method of simultaneously cleaning up the gases in an incandescent electric lamp and of forming a filament resistant to sag and vibration which comprises heating a filament composed of an intimate mixture of tungsten and a metal capable of forming stable compounds with gases in the presence of such gases.

9. A sag and vibration resistant filament comprising tungsten having a large, interlocking crystal structure with tantalum oxide disposed between the crystals.

10. A coiled filament resistant to sag and vibration comprising tungsten having a large interlocking crystal structure with tantalum oxide distributed between the crystals.

11. A filament for incandescent lamps capable of being burned a normal life under vibratory conditions without sagging and having a large interlocking crystal structure with tantalum oxide uniformly distributed between the crystals.

In testimony whereof, I have hereunto subscribed my name this 27th day of July, 1926.

JOHN HUMPHREYS RAMAGE.