Nov. 22, 1966 H. B. SLOAN 3,287,591
TANTALUM CARBIDE INCANDESCENT LAMP AND
METHOD OF MANUFACTURE THEREOF
Filed Dec. 13, 1961

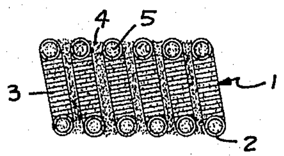

fig-1

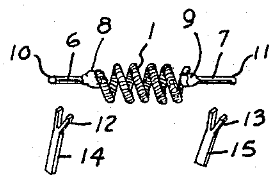

fig-2

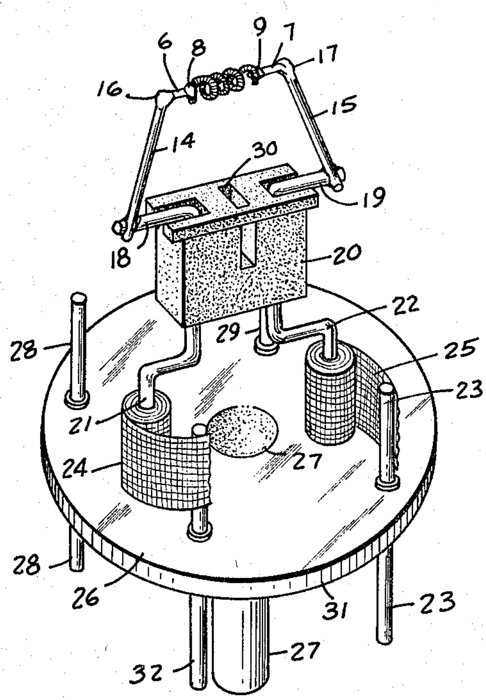

fig-3

HOWARD B. SLOAN
INVENTOR.

BY Laurence Burns.
ATTORNEY

United States Patent Office

3,287,591

Patented Nov. 22, 1966

3,287,591

TANTALUM CARBIDE INCANDESCENT LAMP AND METHOD OF MANUFACTURE THEREOF

Howard B. Sloan, Topsfield, Mass., assignor to Sylvania Electric Products Inc., a corporation of Delaware

Filed Dec. 13, 1961, Ser. No. 159,100
4 Claims. (Cl. 313—271)

This invention relates to incandescent lamps of the type having a filament coil of tantalum carbide or the like. The coil is generally made of a wire of tantalum metal, which is carburized after winding, resulting in a coil of tantalum carbide.

Because of the brittleness of the carbide, the tantalum metal coil has heretofore been mounted in a lamp bulb or on a lamp stem before being carburized. The mounting can thus be done with the wire still metallic, before it is carburized to the brittle carbide. The filament does not have to be handled after the carburizing, for it is already in place on the lamp stem.

Such a procedure is not readily adaptable to high-speed machinery, because each coil has to be carburized separately, by passing current through the coil by either conduction or induction. The lamps or lamp stems, on which the metal coil is mounted, cannot be placed several at a time in a carburizing furnace, because the lamps and stems are usually of glass, which would melt long before the carburizing temperature was reached. Yet the coils cannot simply be placed in a furnace with the proper atmosphere and heated to carburization, because they expand more than 20% in volume during the process, apparently because of the re-crystallization in changing from the metal to the carbide, and this distorts the coil. The turns may move closer together in some places so as to touch and short-circuit, and farther apart in others, the kind of movement depending on the initial stresses produced in each part of the wire during drawing and coiling, thus resulting in a haphazard disordered coil.

Moreover, handling the brittle filament after it is carburized, and any attempt to attach it to lead-in and support wires in a lamp at that stage in the process, is likely to destroy the brittle coil entirely.

These problems become even more acute when the filament is wound into a coiled-coil, the type of winding most commonly used in modern lamp practice.

I have discovered, however, that the coils can be carburized before mounting, if the turns of the coil are filled with graphite powder to hold their shape during the process. A group of coils can then be carburized together in a furnace, and afterward mounted on lamp stems.

When the coil is a coiled-coil, that is a so-called minor coil of small diameter which in itself is wound to form a major coil of large diameter, the graphite packing need only fill the minor coil and the spaces between turns of the major coil. The inside of the major coil need not be filled. In such cases, the minor coil can be first filled with a thin, water suspension of colloidal graphite, held in the minor coil by surface tension, and the graphite powder then pushed into the coil to form a paste, which is afterward dried. The graphite powder can be placed in the coil in various ways, for example with a spatula, but I prefer to place a metal mandrel inside the major coil, and on that as an axis, roll the coil in a layer of graphite powder of sufficient depth to allow filling of the coil.

The coil, after drying, can be heated at a suitable temperature for carburizing, in a proper atmosphere. The movement of the turns, which would take place in an unpacked coil, is now restricted by the graphite packing, which remains in place during the carburizing process.

For reasons to be explained, it is best to use coils which

do not have the outwardly extending legs which are customary in lamp practice. The usual tungsten filament coils have had uncoiled legs extending along or parallel to the extended longitudinal axis of the coil, or when a coiled-coil was used, the main or middle part of the coil was a coiled-coil and the legs simply single coils. The legs maintain their position satisfactorily in the tungsten filament generally used theretofore, and the position of the coil can even be adjusted after mounting, if necessary, by bending the legs. With tantalum carbide, however, such bending of the legs after mounting is impossible, because of the brittleness of the material, and while the configuration of the coil can be maintained by having it packed with graphite during carburization, as described above, the orientation of the legs is difficult to mainatin. The orientation after carburizilng may be incorrect, and bending them to the correct configuration is then impossible.

In a further aspect of my invention, therefor, I carburize the coils without legs, then attach legs to the ends of the coil afterward, for example by cementing them in place. The legs can be of wire-shaped tantalum carbide, for example, and can be cemented to the lead-in wires as well as the coil. The cement used can be a thin paste of tantalum powder in a suitable binder, such as a lacquer, a small amount of cobalt powder being mixed with the tantalum to make the cement more effective.

The lead-in wires can have a notch into which the legs can be inserted to be cemented, the notch being preferably formed by a V-shaped fork at the end of the lead-in wires. The notch will help to keep the leg in place until the cement is set by sintering.

After the carburized coil is mounted on the support or lead-in wires, it is heated in an atmosphere of hydrogen and a hydrocarbon, by passing current through the coil. The heating can be carried to a temperature high enough for effective carburization. Any adhering particles of graphite will be removed by reacting with the hydrogen.

The heating will also burn out the binder in the cement, alloy the tantalum and cobalt therein to some extent, carburize the tantalum powder, evaporate the excess cobalt, and give a sintered bond between the tantalum carbide coil and the tantalum metal support.

To make the bond even stronger, I have discovered that the joint between the tantalum carbide leg and the support wire can be arcwelded in an atmosphere of inert gas, such as argon. That type of welding avoids the shock to the tantalum carbide that would occur if the legs were spot-welded by being contacted by electrodes or if they were clamped in the manner usual in the lamp art. Such a shock could destroy the brittle filament. The lead-in wire to which the legs are welded can be of molybdenum, at least in the region of the weld.

In some prior tantalum carbide lamps, the support wire in that region was of tantalum metal, which absorbs some of the hydrogen which may be present in the finished lamp. If tantalum metal is used for the leads, a visible swelling due to absorption of hydrogen can be seen. The use of molybdenum avoids the absorption and improves the lamp.

When molybdenum support wires are used, molybdenum powder can be used at the joint between the support wire and the filament leg, at least if the joint is later to be arc-welded.

Other objects, advantages and feaures of the invention will be apparent from the following specification, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view, showing a filament coil of tantalum metal, with a packing of graphite powder, and ready to be carburized.

FIGURE 2 shows the carburized filament, with legs attached and ready to be inserted into the notches at the ends of the lead-in wires; and

FIGURE 3 is a perspective view of a finished lamp mount according to the invention, before the mount is sealed into a lamp bulb.

In FIGURE 1, the coil **1** of metallic tantalum wire is a coiled-coil, that is the wire is coiled into a coil **2** of small diameter and this coil **2** itself then wound into a coil **3** of larger diameter. In one coil according to the invention, the tantalum wire had a diameter of 8.5 mils and the first coil was wound to an inside diameter of 14 mils. The number of turns per inch in the first coil was 64, the number of turns per inch in the second coil was 28, and the coil had an axial length of about 0.2 inch. After being wound, the coil was dipped into a colloidal suspension of carbon, for example, the type known commercially as "Aquadag," diluted with about half its volume of water.

The colloidal suspension should preferably just fill the turns of the smaller diameter coil **2**, and the spaces between adjacent turns of the major coil. The suspension can be applied with a spatula, although painting the suspension onto the surface of the wire is often sufficient. A wire mandrel of steel, tungsten or other suitable material is inserted inside the larger diameter coiling, to make a loosely fitting axis around which the coil can turn freely, and the coil, while still wet with the suspension, is rolled in a layer of powdered graphite until the small diameter coil and the spaces between adjacent turns of the major coil are filled with the graphite powder and the colloidal suspension. The resultant filling **4, 5** is in the nature of a paste. The coil is then dried at room temperature or somewhat above but not high enough to boil the water in the paste.

If desired, the use of a colloidal carbon suspension can be omitted and the coil filled directly with graphite powder. The presence of a small amount of liquid binder in the coil will greatly facilitate the application of the graphite powder.

The carbon-packed coil is then placed in a graphite boat, covered with graphite powder, and heated in an electric furnace at a temperature of about 1800° C. for about 40 minutes, the temperature then being raised to about 2200° C. in about 5 minutes and the heating continued for about an additional hour and a quarter. An atmosphere of argon and hydrocarbon or other suitable atmosphere is present in the furnace during the heating.

After the coil is taken out of the furnace the remaining graphite is removed, and each end of the coil **1** is lain across an end of the corresponding leg **6, 7** and a quantity of cement **8, 9** placed around each junction, the cement being composed of 97% tantalum metal powder and 3% cobalt metal powder with sufficient nitrocellulose lacquer to obtain a working consistency. The legs **6, 7** are about 10 mils in diameter and about 3/16 inch long. The free end **10, 11** of leg **6** are then placed in V-shaped notches **12, 13** in support wires **14, 15** and a small quantity of cement **8, 9** as shown in FIG. 3, similar to the above but containing 5% cobalt, is then placed around the junction of the leg **6** and the notch **12**. If the support wires **14, 15** are molybdenum, molybdenum powder can be used instead of the tantalum and cobalt.

The mount is placed in a bell jar (not shown) through which is flowing an atmosphere of hydrogen and hydrocarbon. About 9 amperes current is passed through the filament of about 1/2 minute to raise the temperature to about 2600° C. This will set the cement and sinter the tantalum carbide legs to the coil and leads. The current is reduced to about 7 or 8 amps (to reduce the temperature to about 2100° C.) and heating continued at constant voltage until the current becomes constant. There is usually a rise in current before stability is reached, indicating a change in carbon content and density. This requires about 10 to 30 minutes.

The joint between the leg and lead-in wire is then arc welded. The arc welding may also be applied to the joint **8, 9** between legs **6, 7** and coil **1** to fuse the cement at this point.

The support wires **14, 15** are welded respectively to the intermediate support wires **18, 19**, the latter two wires being held fixed by the ceramic button **20** through which they pass and in which they are tightly held. This results in a firm positioning of the coil **1** in a rigid structure, with the ends **21, 22** of intermediate support wires **18, 19**, being merchanically and electrically connected to the rigid lead-in wires **32, 23**, through the vibration-damping spiral rolls **24, 25** of nickel wire mesh, for example by welding, as in copending patent application Serial No. 62,678, filed October 14, 1960, now Patent No. 3,114,069, by Howard B. Sloan and Sandford C. Peek.

The lead-in wires **32, 23** act as external contact prongs, being sealed through the glass header or disc **26**, having the usual exhaust tube **27**. The additional lead-in wires **28, 29** can help to position the resultant lamp in a sprocket, and can be used to carry a fuse wire, if one is desired in series with the filament, or to support a reflector in optical relationship to the coil **1**. The opening **30** in button **20** can also carry a support for a reflector, if desired. Other suitable types of mount can be used.

In arc-welding the legs, **8, 9** to the support wires **14, 15** the lamp can be placed in an inverted bell jar into which argon gas is flowed at the lower end, at a pressure slightly above atmosphere. The open end of the bell jar will be the top (because of its inverted position) and the lamp mount of FIG. 2 can be supported from the bottom of the bell jar, especially if the diameter of the jar is only slightly larger than that of the header **26**. The argon can enter from a tube in the rounded bottom of the bell jar. The top or open end of the jar can be partially covered by a solid plate, an opening being left through which the welding electrode can be inserted.

The lead-in wires are connected together and to one side of a 220 volt power line. The other side of the line can be connected to a pointed rod-like welding electrode of a suitable material, such as carbon or tungsten, of about 1/16 inch in diameter, a current limiting resistance being connected in series with the electrode, from which an arc of about 1/16 or 1/32 inch is passed to the joint **16, 17** to be welded. A current of about 8 amperes is passed through the arc, and the welding requires only a few seconds. The arc welding in argon can also be done by other suitable methods.

The arc welding makes an effective permanent joint between the leg **6, 7** and the support wire **14, 15**. When the joint is simply heated by passage of current through it and coil **7**, the cement **16** may not become sufficiently hot to sinter the cement and set it properly, because the lead-in wires **14, 15** are thicker than the filament of coil **1**. For this reason arc welding is superior.

The cement **8, 9** used to affix the coil **1** to the legs **8, 9** is nearer the hot coil and so will be more readily heated to the sintering point. However, even there, an improvement is effected by arc welding.

The lead-in wires **32, 23, 28, 29** can be of suitable material well-known in the art, for sealing through the glass used, and the intermediate support wires **18, 19** can be of 40 mil diameter nickel. The support wires **14, 15** are of molybdenum wire 40 mils diameter. The whole mount is then a unitary assembly in which the filament coil of tantalum carbide is supported in a position fixed with respect to the support wires **8, 9** but connected to the lead-in wires **14, 15** only through the vibration-damping mesh springs **16, 17** so that the tantalum carbide coil **1** is protected from any high frequency vibration which may be applied to the header **25** or its rigidly connected parts.

A lamp bulb is then sealed at its open end to the rim **31** of the header **25** to form a complete lamp, as in the previously-mentioned copending application of Howard B. Sloan and Sandford C. Peek. Various other suitable features of the filament mount of that application can be used with the device of the present invention as will be apparent to a person skilled in the art. The lamp can be filled with a suitable gas.

As previously stated, after the graphite packed coil is taken out of the carburizing furnace, the remaining graphite should be removed. This can be done in various ways, for example, by gently "sand-blasting" the coil with an airbrush carrying a stream of firm abrasive particles in a stream of air. A Pasche airbrush, with AEX air-erasing compound, has proven satisfactory. The abrasive can be a firm grit, such as alundum of particles of a size which can pass through about a 200-mesh standard sieve. The air pressure applied to the brush input can be of any suitable value, for example, about 50 pounds per square inch gauge pressure.

Another method of removing the graphite is to put the coil in a container filled with water and then apply a supersonic vibration. The specific coil described was wound so that the second coiling had an inside diameter of 30 mils.

The temperature given in the foregoing specification are so-called "brightness temperatures," that is temperatures measured with a pyrometer. Although a particular embodiment of the invention has been described in detail above, the description is merely by way of illustration and not by way of limitation. Various modifications of the invention will be apparent to a person skilled in the art upon reading the foregoing specification.

What I claim is:

1. A lamp mount including a tantalum carbide coil, a leg cemented to each end of said coil and extending outwardly from it, and a support wire cemented to the otherwire free end of said leg.

2. A lamp mount including a tantalum carbide coil, a leg cemented to each end of said coil and extending outwardly from the coil, and a support wire cemented and arc-welded to the otherwise free end of said leg.

3. A lamp mount including a tantalum carbide coil, a leg cemented to each end of said coil and extending outwardly from the coil, and a molybdenum support wire cemented to the otherwise free end of said leg.

4. The method of making an electric lamp mount, said method comprising fixing the ends of a tantalum carbide filament coil to outwardly extending legs by a cement of tantalum carbide powder in a binder, cementing a different portion of said legs to filament support wires, and then heating the resultant mount at a temperature sufficient to carburize said coil in an atmosphere of a hydrocarbon and hydrogen and to remove the binder and sinter the cement to bond the coil to the legs, and the legs to the support wires.

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JOHN W. HUCKERT, *Primary Examiner.*

GEORGE WESTBY, R. F. POLISSACK,

J. D. KALLAM, *Assistant Examiners.*