Inventor:
Stanley C. Ackerman
by James J. Lagna
His Attorney
MANUFACTURE OF COILED LAMP FILAMENTS

Stanley C. Ackerman, 3979 Northampton, Cleveland Heights, Ohio 44121


Int. Cl. B21f 45/00

U.S. Cl. 140—71.5

5 Claims

ABSTRACT OF THE DISCLOSURE

Coiled filaments of a refractory metal wire are formed by coiling the wire on a tantalum wire mandrel, sintering the wire coil on the mandrel in a vacuum and at an elevated temperature above 1500°C. to recrystallize the wire coil and relieve the strains therein, dissolving out the tantalum mandrel, and then cleaning the wire coil to remove the dissolving medium remaining thereon. The less subject they will be to twisting during operation such as is likely to result in shorting out of the coil turns and premature failure of the filament. An undesirable effect, however, herefore experienced with such higher filament coil sintering temperatures has been the resulting significantly increased amount of blackening that is formed on the bulb wall of the lamp.

Summary of the invention

It is an object of the invention, therefore, to provide a method of manufacturing incandescent lamp filament coils having improved operating characteristics and which produce a materially decreased amount of bulb blackening during lamp operation.

Another object of the invention is to provide a method of manufacturing incandescent lamp filament coils which are less subject to distortion during operation and which have a reduced amount of surface impurities.

Briefly stated, in accordance with one aspect of the invention, the filament coils of electric incandescent lamps are wound or coiled on a tantalum mandrel and sintered thereon at a temperature above 1500°C. as a result of which they do not become contaminated with molybdenum, iron, or other surface layer embedded impurities to a degree such as would produce a significant amount of bulb blackening on vaporization thereof off the filament during lamp operation. Because of the comparatively low vapor pressure of tantalum, the amount of tantalum which diffuses into and thus becomes embedded in the surface layers of the filament coils from the tantalum mandrel during the sintering operation is insufficient, even at comparatively higher sintering temperatures than those customarily employed heretofore, to produce any significant amount of bulb blackening during the operative life of the lamp. In addition, because the filament coils can be sintered at such comparatively higher sintering temperatures and thus recrystallized to a higher degree without causing diffusion thereof into a significant amount of blackening-producing tantalum surface layer impurities, the resulting filament coils are therefore substantially free of internal strains and as a consequence possess uniform operating characteristics and are not subject to twisting during lamp life.

Further objects and advantages of the invention will appear from the following detailed description of species thereof and from the accompanying drawing.

Brief description of the drawing

In the drawings:

FIG. 1 is a elevation of an electric incandescent lamp provided with a coiled filament made by the method comprising the invention;

FIG. 2 is a view illustrating the filament wire coiling step of the filament making method according to the invention;

FIG. 3 is a graph comparing the light maintenance of an electric incandescent lamp provided with a coiled filament made by the method comprising the invention with that of prior type lamps.

Description of the preferred embodiment

Referring to the drawings, FIG. 1 illustrates an electric incandescent lamp of microminiature size and incorporating a filament made by the method comprising the invention. The lamp comprises a glass bulb or envelope 1 having a size, in the case of the particular lamp illustrated, of the order of \( \frac{1}{4} \) inch or so in diameter. It should be understood, however, that the invention is applicable as well as the manufacture of filament for electric incandescent lamps of any bulb size. The bulb or envelope 1 of the particular lamp illustrated is evacuated.
However, if desired, and particularly in the case of larger size incandescent lamps, the bulb 1 may be filled with a suitable inert gas such as argon, or mixtures thereof with other rare gases or with nitrogen, to a pressure preferably below atmospheric.

Sealed into one end of the bulb 1 are a pair of lead-in wires 2 and 3 which are electrically connected at their outer ends to the end contact 4 and the side shell contact 5, respectively, of a lamp base 6 which is suitably fastened to the said end of the bulb, as by conventional basing cement, for example. Interiorly of the bulb, the inner ends of the lead-in wires 2, 3 are electrically connected to and support a coiled wire filament 7 disposed within the bulb 1. The filament 7 is formed of a suitable refractory metal such as tungsten, and it may be either of single coiled or multiple coiled form, e.g., coiled coil.

In accordance with the invention, the filament 7 is made by a process which results in the filament being substantially free of carbon, iron and molybdenum surface layer impurities but containing tantalum diffused into and embedded in its surface layer in a small but effective amount to serve as a getter within the lamp bulb (i.e., for combining with and cleaning up any oxygen that may be present in the filament wire or but insufficient to cause, on its evaporation off the filament during lamp operation, any significant amount of blackening deposit on the inside wall of the lamp envelope during the operative life of the lamp. To this end, it has been found that the concentration of embedded tantalum at the surface of the wire filament should be materially less than about 50 parts, and preferably less than 10 parts per million of the surface composition of the wire filament 7. To satisfactorily perform its gettering action within the lamp bulb, however, the tantalum should be present in the surface layer of the filament wire 7 in an amount of at least a few parts per million of the surface composition of the filament wire.

In the manufacture of the filament 7 according to the invention, the tungsten or other refractory metal wire 8 of which the filament is to be constituted is first tightly wound or coiled to the desired pitch, or number of turns per inch, on a tantalum wire mandrel 9 of the desired wire size or diameter. As shown in FIG. 2, the filament wire 8 may consist of a continuous supply thereof, as on a supply reel or spool 10 for example, and it may be wound or coiled on the tantalum wire mandrel 9, which also reconstitutes as a continuous supply thereof on a supply reel 11, either in the form of a continuous coil or, as shown, in the form of an interrupted coil comprised of a series of coiled sections 12 separated or spaced apart by uncoiled or straight wire sections 13. The coiling of the filament wire supply 8 on the tantalum wire mandrel 9 may be performed in any suitable manner, preferably by means of any conventional type automatic lamp filament coiling machine such as, for example, that shown and described in U.S. Patent 1,227,659, Quackenbush et al., dated May 29, 1917.

The filament wire 8 thus coiled on the tantalum wire mandrel 9 is then immersed in a hot hydrochloric acid bath, heated to a temperature around 80° C, for example, to remove any iron and nickel impurities that may be present on the surface of the filament wire. Following this cleaning operation, the coiled filament wire 8, while still in place on the tantalum wire mandrel 9, is then annealed in an atmosphere at a temperature above 900° C and preferably around 1500° C. or thereabouts, after which the annealing coiled filament wire 8 is then cut in the conventional manner into individual filaments 7 of the desired length, as by severing the filament wire 8 and the associated tantalum wire mandrel 9 by means of metal cutting knives, for instance. The annealing of the coiled filament wire 8 on the wire mandrel 9 serves to relieve enough of the internal strains in the coiled filament wire 8 to prevent any uncoiling or unwinding thereof on the mandrel 9 when it is subsequently cut into the individual filament coil lengths 7. In the particular spaced-coiling adaptation shown in FIG. 2, the coiled filament wire 8 and the associated tantalum wire mandrel 9 are simultaneously cut approximately midway of the length of the straight sections 13 of the filament wire, at the cutting planes denoted by the dash-dot lines P, to thereby form the individual filament coils 7. Where coil lengths 7 of multiple coiled, e.g., coiled, form are desired, the annealed coiled filament wire 8 and associated tantalum wire mandrel 9, before the cutting thereof into the individual filament coil lengths 7, is in that case coiled again on a secondary mandrel (not shown) which, in accordance with the invention, is likewise made of tantalum. The coiled coif filament wire 8, while still in place on the primary and secondary tantalum wire mandrels, is then cleaned in a hot hydrochloric acid bath and again annealed, in the case manner as described above, following which it is then cut into individual coiled-coil filament lengths. The severed filament coils 7, while still in place on the cut lengths of tantalum wire mandrel 9, then are preferably again immersed in a heated hydrochloric acid bath, as before, to remove any iron or nickel impurities, or any other but insufficient to cause, on its evaporation off the filament during lamp operation, any significant amount of blackening deposit on the inside wall of the lamp envelope during the operative life of the lamp. To this end, it has been found that the concentration of embedded tantalum at the surface of the wire filament should be materially less than about 50 parts, and preferably less than 10 parts per million of the surface composition of the wire filament 7. To satisfactorily perform its gettering action within the lamp bulb, however, the tantalum should be present in the surface layer of the filament wire 7 in an amount of at least a few parts per million of the surface composition of the filament wire.

After they have been thus cleaned, the individual filament coils 7, with the tantalum wire mandrels 9 still in place thereof, are then inserted, under vacuum, at the required sintering temperature and for the required period of time, generally from 10 minutes to a few hours, to crystallize the tungsten or other refractory metal of which the filament coils are made to the desired degree, and to also relieve the internal stresses remaining in the filament wire, the filament coils 7 thereby being `set' so as to retain their coiled form, and not uncoil, when the wire mandrels 9 are subsequently removed therefrom. The sintering of the filament coils 7 may be carried out in a vacuum furnace under a high degree of vacuum, of, for example, around 10−5 pounds per square inch or better. The temperature at which the filament coils 7 are sintered may range anywhere from around 1600° to 2500° C. or thereabouts, depending on the degree of grain growth desired for the particular refractory metal of which the filament coils 7 are composed. To realize the fullest advantages of the invention, however, the sintering of the filament coils 7 should be carried out at the higher regions of the above-stated range of suitable sintering temperatures in order to thereby effect a greater degree of grain growth of the filament metal, and relieve the internal strains therein to a greater degree, as a consequence of which the filament coils 7 are considerably more uniform in their physical and operating characteristics and less subject to twisting and resultant shorting out of the coil turns during lamp operation. The choice of sintering temperature employed, however, will depend on the degree of brittleness of the tungsten or other refractory metal filament coil 7 which can be tolerated in the particular lamp application, it being well known that the higher the sintering temperature the lesser the degree of ductility of the tungsten filament coil at room temperature. Thus, for filaments of very small wire size, it is necessary to employ sintering temperatures within the lower regions of the above-stated range of suitable sintering temperatures in order to thereby effect a greater degree of ductility of the tungsten filament coil at room temperature. Such small wire size filaments become exceedingly brittle, and therefore difficult to handle without breakage, at the higher sintering temperatures.

After the filament coils 7 with their respective tantalum wire mandrels 9 still in place therein have been thus sintered, the tantalum wire mandrels are then suitably removed from the filament coils. The removal of the tantalum wire mandrels is preferably accomplished by chemically dissolving them out of the filament coils, as customary practice heretofore in the manufacture of
incandescent lamp filament coils. For this purpose, the filament coils 7 may be immersed in a hydrofluoric acid bath heated to a temperature near the boiling point thereof, for example around 80° C. or so. Thereupon, the filament coils 7 are suitably cleaned, as by rinsing them in distilled water for instance, after which they are then stored in glass or other suitable containers in readiness for use in the manufacture of incandescent lamps comprising the invention.

As clearly evident from the curves designated A and B in the chart shown in FIG. 3, the light maintenance of electric incandescent lamps provided with tantalum mandrel wound filament coils 7 according to the invention is greatly improved over that of corresponding lamps provided with filament coils wound on molybdenum or steel mandrels. The curves A and B in FIG. 3 are the plots of the percent of initial light output, at various hours of lamp burning time, of lamps provided with tantalum mandrel wound filament coils and molybdenum mandrel wound filament coils, respectively, the lamps being of substantially the same construction throughout except for the tungsten filament coils and having substantially the same initial light output at zero burning hours. The particular lamps represented by the curves A and B in FIG. 3 are of the T ¾ microminiature bulb size, employing a small tungsten coil of a diameter of % of one-eighth inch, i.e., %, ¼ inch, and a length of about % inch, and provided with tungsten filament coils 7 of 5 volt .06 amperes rating, which have been sintered at approximately 1600° C.

Referring to the curves shown in FIG. 3, it will be seen that during the initial lamp seasoning time of around 20 hours so of operation, during which time the tungsten of the filament coil 7 is further recrystallized the light output of lamps provided with tantalum mandrel wound tungsten filament coils made in accordance with the invention (curve A) increases by about 15 to 20% or so and thereafter remains substantially constant. In contrast therewith the light output of lamps generally made heretofore, provided with molybdenum mandrel wound tungsten filament coils (curve B) undergoes an appreciable initial decrease amounting to around 15 to 20% (due mainly to the deposition on the bulb wall of the molybdenum surface impurities rapidly vaporized off the filament during the initial lamp seasoning time of around 20 hours or so, and thereafter continues to progressively fall off and decrease during the operating life of the lamp so that at 2000 hours, for example, the light output is only around 60% or so of the initial light output. Thus, at 2000 hours of burning time, the light output of lamps provided with molybdenum filament coils made in accordance with the invention is almost twice that of lamps heretofore generally made employing molybdenum mandrel wound tungsten filament coils. This, of course, is a most important and highly desirable advantage and has made possible, and commercially practical, the production of microminiature and other small size incandescent lamps which are of stable character and are capable of producing an effective or useful amount of light for a relatively long period of operating time ranging up to hundreds, and even thousands, of hours.

The improved light maintenance of incandescent lamps provided with coiled tungsten filament coils made in accordance with the invention, as compared to prior type incandescent lamps which are generally provided with filament coils which have been wound on molybdenum or steel mandrel wire, is due mainly to the fact that the filament coils provided in the lamp, those impurities vaporizing out of the filament wire during lamp operation and depositing on the inside wall of the lamp bulb to form a blackening deposit thereon which absorbs the light rays radiated by the filament lamp. These molybdenum and iron surface layer impurities are introduced into filament coils which have been wound on molybdenum or steel mandrel wire by the vaporization of the molybdenum or iron off the molybdenum or steel mandrels during the high temperature sintering of the coiled filament wire while positioned on the molybdenum or iron then being diffused or driven into the surface layer of the coiled filament wire. Because of the comparatively low vapor pressure of tantalum, however, compared to molybdenum or iron, the amount of tantalum that is evaporated off a tantalum wire mandrel and diffused or driven into the surface layer of the coiled filament wire 8 thereon during the sintering treatment of the coiled filament wire, is many times less, i.e., around 900 or more times less, than the amount of molybdenum or iron which is evaporated off a molybdenum or steel mandrel and driven into the surface layer of the coiled filament wire under the same sintering conditions, i.e., the same sintering temperature and time. As a result, the tantalum surface layer embedded impurities present in the filament coils 7 according to the invention are so insignificant that their presence will produce little, if any, blackening deposit on the inside wall of the lamp bulb. Moreover, because of the high characteristic of having an affinity for and readily combining with oxygen and hydrogen, the comparatively small amount of tantalum that is actually driven into the surface layer of the filament coil 7 of the invention during the sintering thereof on the tantalum mandrel wire 9 beneficially acts as a getter within the lamp, the vaporized from the tantalum filament or occupying a surface site on the cooler filament portions near the connections of the filament to the lead-in wires 2 and 3, to combine with any oxygen or hydrogen that may be driven out of the filament wire or out of the bulb wall during lamp operation, and would normally have a deleterious effect on the filament.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of making a coiled lamp filament comprising the steps of coiling a refractory metal wire on a tantalum wire mandrel, sintering the coiled refractory metal wire on the mandrel by exposure thereof to an ambient temperature above 1500° C. for a period at least ten minutes in a vacuum in a vacuum furnace to enlarge the grain size of the refractory metal wire and relieve the strains therein, immersing the coiled refractory metal wire in a heated bath of hydrofluoric acid to dissolve out the tantalum mandrel, and then rinsing the refractory metal wire coil in a cleansing bath to remove the hydrofluoric acid remaining on the surface of the wire coil.

2. The method of making a coiled tungsten wire lamp filament comprising the steps of coiling tungsten wire on a tantalum wire mandrel, immersing the coiled tungsten wire on the mandrel in a heated bath of hydrochloric acid to remove surface impurities on the tungsten wire coil, annealing the tungsten wire coil on the mandrel at a temperature above 900° C. and in an inert atmosphere, sintering the coiled tungsten wire on the mandrel by exposure thereof to an ambient temperature above 1500° C. for a period of at least ten minutes in a vacuum in a vacuum furnace to enlarge the grain size of the tungsten wire and relieve the strains therein, immersing the coiled tungsten wire on the mandrel in a heated bath of hydrofluoric acid to dissolve out the tantalum mandrel, and then rinsing the tungsten wire coil in a cleansing bath to remove the hydrofluoric acid remaining on the surface of the wire coil.

3. The method of making a coiled tungsten wire lamp filament comprising the steps of coiling tungsten wire on a tantalum wire mandrel, immersing the coiled tungsten wire on the mandrel in a heated bath of hydrochloric acid to remove surface impurities on the tungsten wire
3,461,921

5. The method of making coiled tungsten wire lamp filaments comprising the steps of coiling tungsten wire on a tantalum wire primary mandrel, immersing the coiled tungsten wire on the primary mandrel in a heated bath of hydrochloric acid to remove surface impurities on the tantalum wire mandrel, annealing the coiled tungsten wire coil on the mandrel at an elevated temperature above 900° C. and in an inert atmosphere, coating the coiled tungsten wire and primary mandrel assembly on a secondary tantalum wire mandrel, immersing the coiled-tungsten wire on the primary and secondary mandrels at an elevated temperature above 900° C. and in an inert atmosphere, cutting the coiled-tungsten wire and associated primary and secondary mandrels into individual tungsten wire filament coils, immersing the cut filament coils in a heated bath of hydrochloric acid to remove any remaining surface impurities on the said mandrels, cutting the grain size of the tungsten wire and relieve the strains therein, immersing the filament coils on the said mandrels in a heated bath of hydrofluoric acid to dissolve out the tantalum mandrels, and then rinsing the filament coils in a cleaning bath to remove the hydrofluoric acid remaining on the surface thereof.

3. The method of making coiled tungsten wire lamp filament comprising the steps of coiling tungsten wire on a tantalum wire primary mandrel, immersing the coiled tungsten wire on the primary mandrel in a heated bath of hydrochloric acid to remove surface impurities on the tantalum wire mandrel, annealing the coiled tungsten wire coil on the mandrel at an elevated temperature above 900° C. and in an inert atmosphere, coating the tungsten wire coil and primary mandrel assembly on a secondary tantalum wire mandrel, immersing the resultant tungsten wire coiled-coil on the primary and secondary mandrels in a heated bath of hydrochloric acid to remove surface impurities on the coiled-coil, annealing the tungsten wire coiled-coil on the primary and secondary mandrels at an elevated temperature above 900° C. and in an inert atmosphere, sintering the tungsten wire coiled-coil on the primary and secondary mandrels by exposure thereof to an ambient temperature above 1500° C. for a period of at least ten minutes in a vacuum in a vacuum furnace to enlarge the grain size of the tungsten wire and relieve the strains therein, immersing the tungsten wire coiled-coil on the said mandrels in a heated bath of hydrofluoric acid to dissolve out the tantalum mandrels, and then rinsing the tungsten wire coiled-coil in a cleaning bath to remove the hydrofluoric acid remaining on the surface of the wire coil.

References Cited
UNITED STATES PATENTS
1,992,797 2/1935 Zabel .................. 72—128
2,165,105 7/1939 Krejci et al. .............. 72—128
3,285,293 11/1966 Matheson ............ 140—71.5

CHARLES W. LANHAM, Primary Examiner
LOWELL A. LARSON, Assistant Examiner

U.S. Cl. X.R.
72—128
CERTIFICATE OF CORRECTION

Patent No. 3,461,921 Dated August 19, 1969

Inventor(s) Stanley C. Ackerman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 4, after "44121" add:

--assignor to General Electric Company,

a corporation of New York--

SIGNED AND SEALED
MAY 26 1970

(SEAL)
Attest:
Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents