May 12, 1964

G. A. FREEMAN

3,132,409

PROCESS FOR ASSEMBLING ELECTRODES

Filed Dec. 22, 1959

FIG. 1.

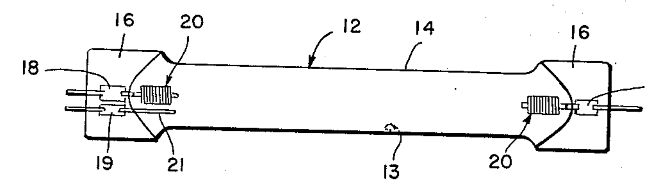


FIG. 2.

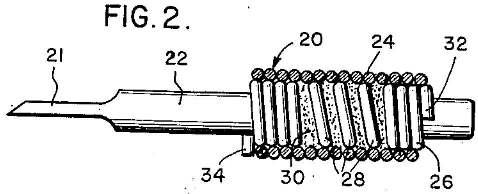


FIG. 3.

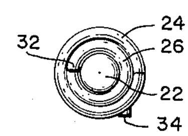


FIG. 4.

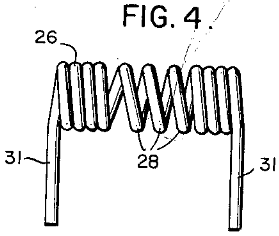


FIG. 5.

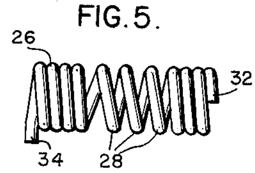


FIG. 6.

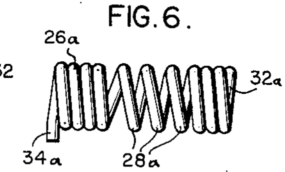


FIG. 8.

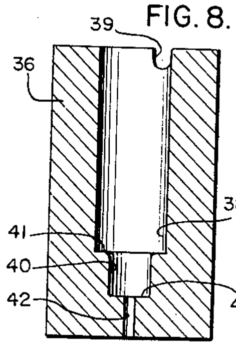


FIG. 7.

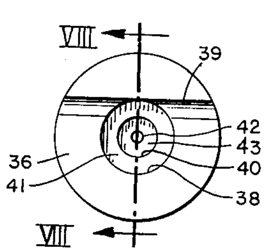


FIG. 11.

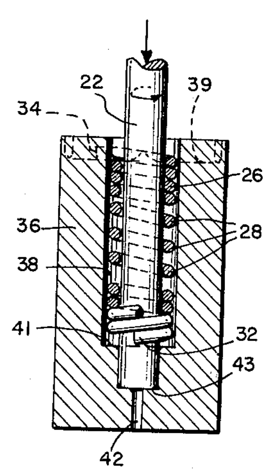
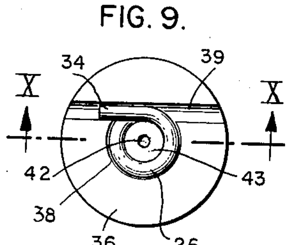


FIG. 9.



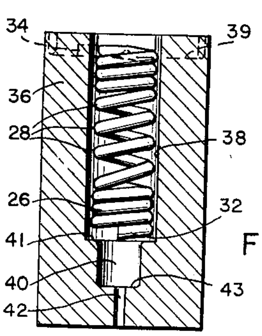


FIG. 10.

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PROCESS FOR ASSEMBLING ELECTRODES

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5 Claims. (Cl. 29—25.14)

This invention relates to a thermionic electrode for an electric discharge device and, more particularly, to a process for conveniently assembling such electrodes.

Recently there has been marketed in this country an improved thermionic electrode for high pressure mercury vapor (HPMV) lamps that markedly increases both the useful life and lumen maintenance of such lamps by providing a reservoir of electron-emissive material that is shielded from the gaseous discharge and the erosive effect thereof. This is accomplished by depositing the emission material by means of a dip process between the spaced intermediate turn or turns of a refractory wire coil that has closed end sections and is mounted on a suitable core member such as a tungsten rod. A tightly wound outer coil is then threaded over and interlocked with the inner coil. This encloses the expanded medial section of the inner coil and the reservoir of emission material therein. The emission material is thus protected from the arc and the sputtering of such material onto the bulb surface and resultant progressive blackening of the bulb is markedly reduced.

To avoid time-consuming and costly integrating operations such as welding or the like the inner coil and core member are preferably dimensioned so that they can be locked together by means of a force fit. However, since the inner coil must be tightly fitted onto the rod so as to permit the outer coil to be threaded over the inner coil and locked therewith without displacing the latter, it frequently happened that the expanded medial section of the inner coil partially collapsed and became permanently distorted as the rod was being inserted. When this occurred the inner coil had to be discarded since the spacing between turns of the expanded section was decreased and this section thus could not hold or accommodate the required amount of emission material. Narrowing the diameter tolerances of the rod and inner coil as much as practical to minimize the compressive stress on the inner coil and the tendency of the medial section to collapse during assembly failed to solve this problem.

It is accordingly the general object of the present invention to overcome the foregoing and other problems associated with the assembly and use of composite thermionic electrodes of the aforesaid character.

Another and more specific object is the provision of a method which will enable the core rod and inner coil component of such an electrode to be assembled with a minimum amount of labor and shrinkage and which can be readily adapted to automatic assembly techniques.

The aforesaid objects of the invention, and others which will become apparent as the description proceeds, are achieved by holding the inner coil to prevent it from turning or being displaced in an axial direction, but without constricting it or obstructing access to its interior, and then concurrently rotating the core rod and inserting it into the coil while the latter is so held. Rotation of the rod during its insertion causes the coil to relax or "open up," so to speak, and thus permit the necessary force to be exerted on the rod without causing the expanded medial section of the coil to collapse or become distorted, especially if the rod is rotated at a predetermined rate of speed and in a predetermined direction with respect to the direction in which the coil was wound.

A better understanding of the invention and the manner

in which the aforementioned objectives are attained can be had by referring to the accompanying drawing, wherein:

FIG. 1 is a side elevational view on a reduced scale of an arc tube for an HPMV lamp which incorporates thermionic electrodes assembled in accordance with this invention;

FIG. 2 is an enlarged side elevational view, partly broken away and in section, of one of the electrodes of the arc tube shown in FIG. 1;

FIG. 3 is an end view of the arc-supporting portion of the electrode illustrated in FIG. 2;

FIGS. 4 and 5 are side elevational views of the inner coil before and after the coil legs have been trimmed, respectively;

FIG. 6 is a side elevational view of an alternative coil embodiment;

FIG. 7 is a plan view of a preferred form of coil holder;

FIG. 8 is a cross-sectional view of the holder taken along the line VIII—VIII of FIG. 7, in the direction of the arrows;

FIG. 9 is a plan view of the coil holder corresponding to the view shown in FIG. 7 but with the coil illustrated in FIG. 5 inserted into the holder and locked in keyed relation therewith;

FIG. 10 is a cross-sectional view of the holder and inserted coil taken along the line X—X of FIG. 9, in the direction of the arrows; and

FIG. 11 is a side-sectional view of the coil and holder similar to the view shown in FIG. 10 but with the core rod in its assembled relation with the coil preparatory to the withdrawal of the rod-and-coil assembly from the holder.

While the present invention can be advantageously employed in assembling various kinds of devices wherein one member is force-fitted into another member that is susceptible to distortion when compressively stressed, it has particular utility in connection with the assembly of thermionic electrodes for HPMV lamps and has accordingly been so illustrated and will be so described.

With specific reference to the form of the invention shown in the drawing, in FIG. 1 there is shown an arc tube **12** for an HPMV lamp comprising a tubular envelope **14** of quartz or the like that is closed at each end by a press seal **16**. A pair of oppositely disposed thermionic electrodes **20** are anchored in each of the seals **16** and electrically connect with the usual ribbon-conductor assemblies **18** which are hermetically embedded in and extend through the aforesaid seals. A filling of ionizable starting gas such as argon or the like is also sealed within the envelope **14** along with a charge of mercury **13** and an auxiliary electrode **21** that is disposed adjacent one of the main electrodes **20** and electrically connects with a separate ribbon-conductor assembly **19**.

As shown more particularly in FIGS. 2 and 3, each of the main electrodes **20** consist generally of an outer coil **24** and an inner coil **26** of linear configuration, and a core member such as a cylindrical tungsten rod **22** that is inserted into and locked by means of a force fit with the inner coil. Both the outer coil **24** and the inner coil **26** are of substantially uniform diameter and are wound from refractory metal wire such as tungsten for example. The outer coil **24** is tightly wound so as to form a closed helix and is threaded over and interlocked with the inner coil **26** the end turns whereof are also tightly wound and constitute closed end sections. The intermediate turns **28** of the inner coil **26** are spaced a predetermined distance from each other and from the adjacent end turns and constitute an expanded medial section that is filled with a predetermined amount of suitable electron-emissive material 30 such as the well-known alkaline earth carbonates, thoria, etc., or mixtures thereof. The emission material 30 is preferably applied by mixing it with a suitable binder to form a slurry and dipping the rod-and-inner coil assembly therein. Upon hardening the emission material firmly adheres to and bridges the intermediate turns 28 as shown. The end of the rod 22 opposite the aforesaid coils is preferably shaped to provide a flat end section 21 in order to facilitate the electrical connection thereof with the ribbon-conductor assembly 18 and its subsequent embedment in the press seal 16. The aforesaid inner and outer coils are preferably located a predetermined distance inward from the cylindrical end of the core rod 22 as shown.

The present invention relates to an improved method for assembling composite type electrodes of the aforesaid character rather than to such electrodes per se and this method will now be described.

Since the method can be most conveniently practiced with a specific type of inner coil component, two examples of such components will first be described. In FIG. 4 there is shown one design wherein the inner coil 26 as wound has a leg 31 at each end which protrude at right angles from the same side of the coil. Instead of cutting both legs 31 in a direction parallel to the longitudinal axis of the coil as heretofore to provide a so-called "square cut" end turn 32 such as that shown in FIG. 5, only one leg is thus processed and the other severed at a point located a predetermined distance from the coil body. Thus, at least one of the end turns of the inner coil 26 is terminated by a substantially straight end segment 34 that protrudes laterally from the outer surface of the coil body and constitutes a tangential extension of the aforesaid end turn, as illustrated in FIGS. 2, 3 and 5. To facilitate anchoring the end segment 34 in the manner hereinafter described, said segment projects beyond the outer surface of the coil a distance at least equivalent to the diameter of the wire from which the inner coil is wound and preferably about twice the wire diameter. This permits the leg 31 at that end of the coil to be cut while the coil is still on the coiling machine thus affording the additional advantages of reducing the cost of the coil by eliminating at least one of the manual cutting operations heretofore required and the resultant burr at the entrance to the coil that necessitated, in turn, a deburring operation and the maintenance of close diameter tolerances to permit easy insertion of the rod 22.

Alternatively, instead of employing a cutting wheel to form the "square cut" end turn 32 the coil leg 31 can be cut in a direction normal to the longitudinal axis of the coil to provide another type of inner coil 26*a* which has an end turn 32*a* that is tapered rather than terminated abruptly, as shown in FIG. 6. This type coil is preferred since both ends of the coil can then be trimmed by machine instead of manually as heretofore thereby further reducing the manufacturing cost of the coil.

Assembly of the core rod 22 with the inner coil 26 is accomplished in accordance with this invention by concurrently rotating and inserting the rod into the coil while the latter is held in such a manner that displacement thereof in both an axial and radial direction is prevented, without obstructing the entrance of or access to the interior of the coil along a path coincident with the longitudinal axis thereof. A preferred apparatus for holding the inner coil 26 during the assembly thereof with the rod 22 in accordance with the foregoing procedure is illustrated in FIGS. 7 and 8. As there shown, the holder comprises a rigid support member 36 having a major cavity 38 that extends inwardly from one end of said member and merges with a minor cavity 40 that opens into and coaxially extends from the bottom of said major cavity. Both of the aforesaid cavities are of cylindrical configuration, the major cavity being at least as long as but slightly larger in diameter than the outside diameter of the inner coil 26, as for example .010 of an inch in the case of a 1000 watt coil that has an outside diameter of approximately .149 of an inch. The minor cavity 40 is slightly larger than the diameter of the rod 22 and has a length equal to the distance between the cylindrical end of the rod 22 and the outermost turn 32 of the inner coil 26 when the latter is locked in its position of use on said rod.

Due to the difference in diameter of the aforesaid major and minor cavities there is provided an inwardly protruding annular shoulder 41 at the bottom of the major cavity 38 which is adapted by virtue of its location to serve as a stop for the inner coil 26 when the latter is placed into the holder as set forth below. A recess such as a groove 39 is provided in the face of the support member 36 which groove communicates with and extends tangentially from the major cavity 38, as shown most particularly in FIG. 7. The depth of the groove 39 is at least equivalent to the diameter of the wire from which the inner coil 26 is wound and is of sufficient length to accommodate the uncoiled end segment 34. The minor cavity 40 may be vented to the atmosphere as by a passageway 42 that extends from the bottom thereof to the proximate face of the support member 36.

To assemble the rod 22 with the inner coil 26 the end of the coil opposite the end with the uncoiled end segment 34 is inserted into the support member 36 and the coil oriented so that the aforesaid end segment falls into the groove 39. The inner coil 26 is thus locked or keyed with the support member 26 and prevented from turning and is seated against and supported by the annular shoulder 41 at the bottom of the major cavity 38, as shown in FIGS. 9 and 10. The core rod 22 is then concurrently rotated about its own axis and inserted into the inner coil 26 along a path coincident with the longitudinal axis thereof, the rod preferably being rotated in a direction opposite to the direction of rotation defined by the turns at the entrance end of the coil (as illustrated in FIG. 11). This causes the coil to "open up" or relax, so to speak, and be temporarily enlarged thus permitting the rod to be inserted without compressively distorting the intermediate turns 28 of the coil. It has been found that the rod 22 can be inserted with a minimum of thrust when it is rotated at approximately 60 r.p.m. or less and for this reason speeds in this order of magnitude are preferred. However, the speed of rotation is not critical and can be varied considerably.

The axial thrust on the rod 22 is continued until the cylindrical end thereof seats against the bottom 43 of the minor cavity 40 and the inner coil 26 thus precisely located in its position of use on the rod. Rotation of the rod is then stopped and the rod-and-coil assembly withdrawn from the support member 36 and the subsequent operations required to complete the fabrication of the electrode 20 are carried out.

It has been found that by assembling the rod 22 and inner coil 26 in the foregoing manner the shrinkage due to distorted coils during rod insertion surprisingly dropped from about 25% and higher to less than 2%.

It will be apparent that the inner coil 26 can be prevented from turning within the holder by means other than the above-mentioned combination of an interlocking groove 39 and uncoiled end segment 34. For example, the end of the "square cut" end turn 32 could be engaged and the coil thus prevented from turning by means of a suitable stop that projects either from the annular shoulder 41 or the side wall of the major cavity 38, in which case the aforesaid uncoiled end segment or groove would not be required.

It will be recognized from the foregoing that the objects of the invention have been achieved by providing an improved method of assembling the rod and coil components of a composite thermionic electrode, which method not only reduces the manufacturing cost of the coil but can be readily adapted to automatic manufacturing techniques.

While one embodiment of the invention has been illustrated and described, it is to be understood that various modifications can be made therein without departing from the spirit and scope of this invention.

I claim:

1. In the manufacture of a composite electrode comprising a refractory wire coil of linear configuration and a core member having an end portion that is larger in cross-section than the inside diameter of said coil by an amount sufficient to enable the coil to be locked in assembled relationship on said core member solely by means of a force fit, the method of assembling said wire coil and core member without permanently distorting the coil and changing the spacing between the turns thereof comprising;

holding one end of the coil at a location such that the coil is held stationary and its interior is accessible along a path coincident with the longitudinal axis of the coil,

rotating the core member about its longitudinal axis, inserting the end portion of said rotating core member into the aforesaid end of said coil along said path to temporarily enlarge the portion of said coil engaged by said core member and thereby enable the latter to freely enter the coil,

continuing the concurrent rotation and insertion of said core member until said coil is located in its assembled position on said core member, and then

discontinuing the rotation and axial movement of said core member to permit the temporarily enlarged portion of said coil to return to its original size and thus compressively grip the core member.

2. The method of assembling a refractory wire coil and a core member as set forth in claim 1 wherein the coil is so oriented with respect to the rotating core member that the turns of said coil beginning at the entrance end thereof define a direction of rotation that is opposite to the direction in which the core member is being rotated.

3. In the manufacture of a composite electrode comprising a refractory wire coil of linear configuration having an end turn that is terminated by an uncoiled end segment which protrudes laterally beyond the body of said coil, and a support rod having a cylindrical end portion that is larger in diameter than the inside diameter of said coil by an amount sufficient to enable the coil to be locked in assembled relationship on said rod solely by means of a force fit, said coil having at least one intermediate turn that is spaced a predetermined distance from the adjacent turns and constitutes an expanded medial section that is adapted to hold a predetermined amount of emission material and tends to collapse and become shorter when said coil is compressed in an axial direction, the method of assembling said coil and rod without substantially permanently distorting or altering the length of said expanded medial section, which method comprises;

engaging the laterally protruding end segment of said coil turn to prevent the coil from turning and moving in an axial direction without rendering its interior inaccessible along a path substantially coincident with the longitudinal axis of the coil,

rotating the support rod about its longitudinal axis at a predetermined rate of speed and in a direction opposite to the direction of rotation defined by the turns of said coil beginning at said laterally protruding end segment,

inserting the cylindrical end portion of said rotating rod into said coil along the aforesaid path to temporarily enlarge the portion of said coil engaged by said rod and enable the latter to be freely inserted therein,

continuing the concurrent rotation and insertion of said rod until the cylindrical end portion thereof extends through said coil and the latter is disposed in assembled relationship with said rod, and then

discontinuing the rotation and axial movement of said rod to permit the temporarily enlarged portion of said coil to return to its original size and thus compressively grip the rod.

4. The method of assembling the refractory wire coil and support rod components of a composite electrode as set forth in claim 3 wherein the free end of said coil is seated against and supported by an apertured stop member during the assembly operation.

5. The method of assembling the refractory wire coil and support rod components of a composite electrode as set forth in claim 3 wherein said rod is rotated at a speed of approximately 60 r.p.m.

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