United States Patent

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[73] Assignees **Republic National Bank of Dallas; Irving Trust Company; Union Bank**
Original application Oct. 24, 1967, Ser. No. 677,565, now Patent No. 3,518,480, dated June 30, 1970. Divided and this application Oct. 13, 1969, Ser. No. 871,201

[54] **ARC LAMP CONSTRUCTION**
4 Claims, 10 Drawing Figs.

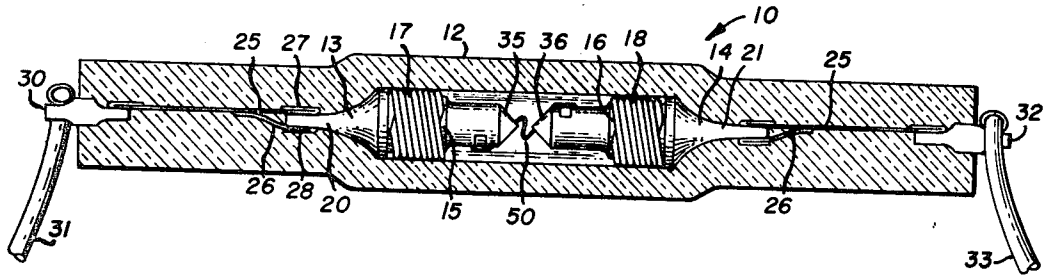
[52] **U.S. Cl.** **29/25.16,** 29/25.13, 316/19
[51] **Int. Cl.** **H01j 9/36,** H01j 9/18
[50] **Field of Search** 29/25.1, 25.11, 25.13, 25.15, 25.16; 316/19, 24, 30

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ABSTRACT: An arc lamp construction in which the lamp envelope portion surrounding the main body portions of the arc electrodes is spaced therefrom to define a cylindrical gap and in which a packing member is disposed in the cylindrical gap to support the electrodes. The packing member is elastic, or radially deformable, to prevent cracking of the envelope as the gap width changes with temperature, and is thermally conductive to allow the transfer of electrode heat across the gap to the envelope.



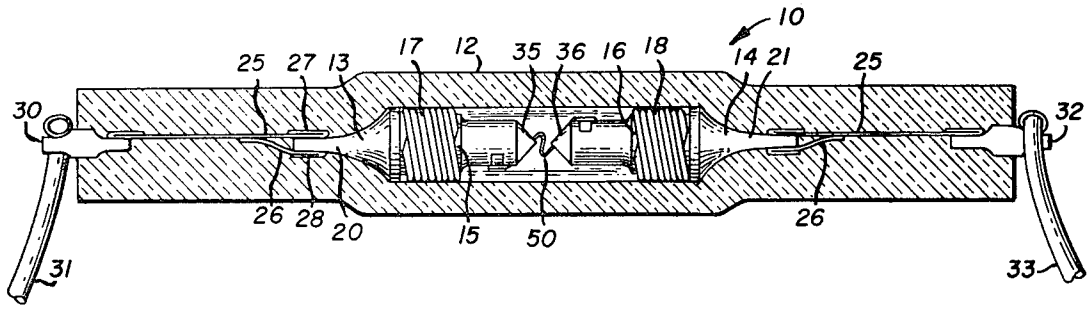


Fig_1

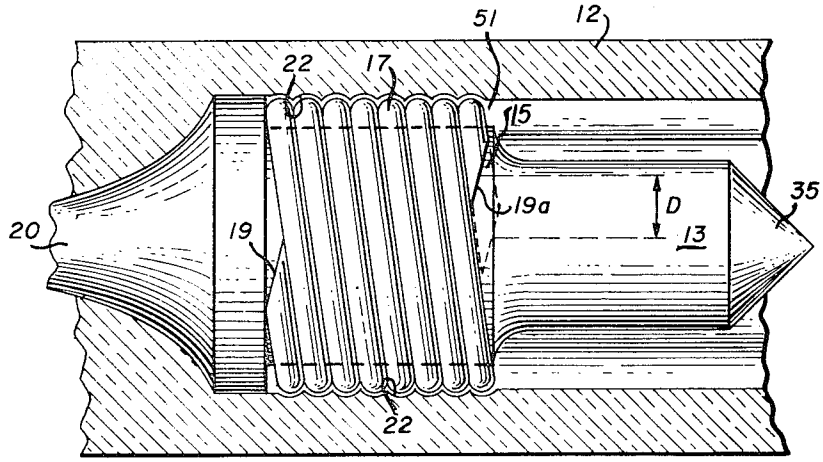


Fig_2

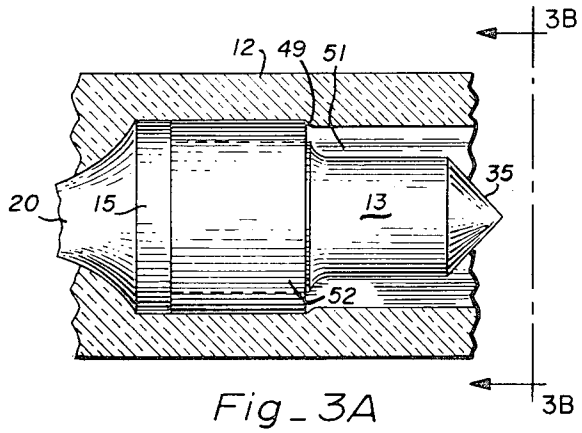


Fig_3A

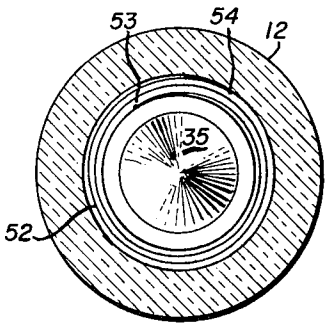


Fig_3B

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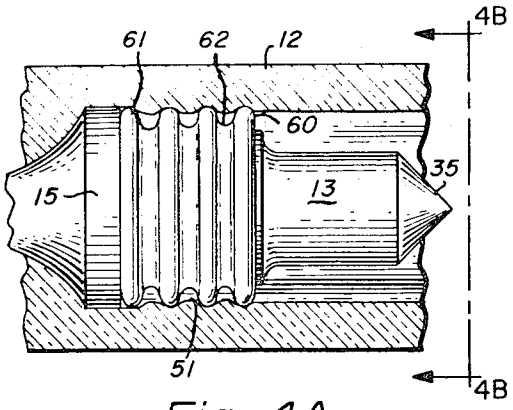


Fig_4A

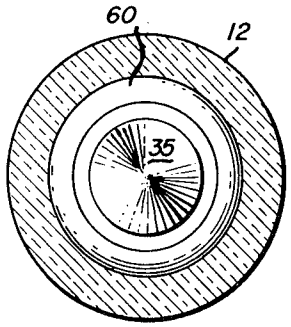


Fig_4B

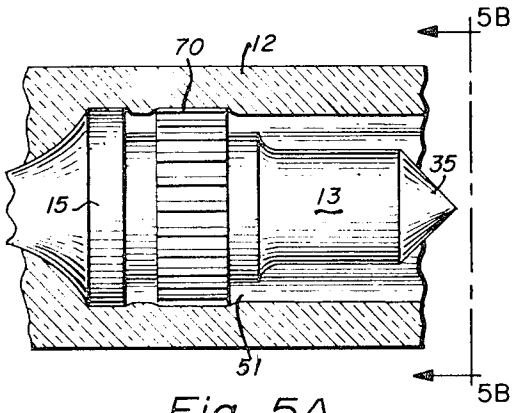


Fig_5A

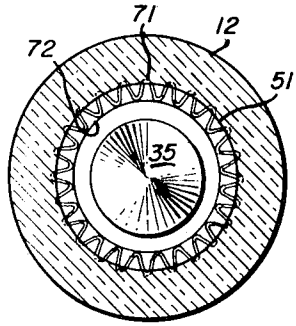


Fig_5B

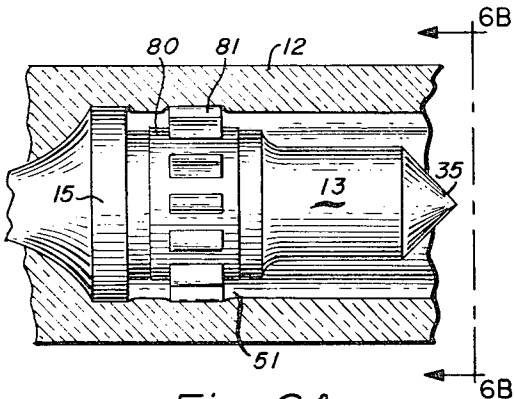


Fig_6A

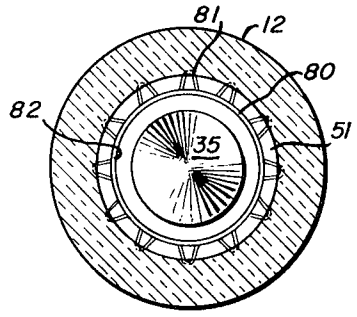


Fig_6B

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ARC LAMP CONSTRUCTION

This application is a division of my copending application Ser. No. 677,565, filed Oct. 24, 1967, now U.S. Pat. No. 3,518,480.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to arc lamps, and, more particularly, to an arc lamp construction that is capable of withstanding severe shock and vibration by the provision of an electrode support in the nature of a soft packing that also aids in maintaining precision alignment of the electrodes and improves the heat transfer from the electrodes to the envelope, and thereby lengthens the useful operating life.

For certain arc lamp applications the arc lamp is exposed to an environment which makes extremely high demands on the mechanical and electrical integrity of the lamp. For example, in missile and rocket applications, an arc lamp has to withstand severe shock and vibration, and consequently requires very firm anchoring of its electrodes to prevent electrodes from shaking loose and to maintain a constant arc gap. Further, since weight and space are always problems in missile and rockets, a light and small arc lamp is always desired. Since the required useful lifetimes are usually short, such arc lamps can be run above their normal rating for short times, thereby allowing a much lighter and smaller arc lamp to be used.

The major problem encountered in arc lamp constructions which have good survival capabilities to vibration and shock, and which may be overdriven to provide a minimum required amount of illumination above its normal rating, is that the refractory electrode material has a coefficient of expansion which is about eight times greater than the radiation transparent envelope material. Accordingly, to securely support the electrodes within the envelope requires the envelope to be tightly or hard-shrunk upon the electrode body. However, if this is done when the electrode is cold, the subsequent heating of the electrodes during arc operation will fracture the envelope because of the unequal rate of expansion. If the envelope is hard-shrunk upon the electrode to provide a tight fit at normal operating temperatures, then the electrodes will be loose prior to reaching their normal operating temperature, and will be subject to destruction when exposed to shock and vibration. Additionally, it is almost impossible to control manufacturing tolerances so closely that a good tight fit between the envelope and the electrode at a usually ever-increasing operating temperature can be accomplished. This is particularly true since heat dissipation from the electrode to the envelope is best when the contact is good.

2. Description of the Prior Art

One type of arc lamp which is particularly suited for missile-type applications is the self-starting short arc lamp which utilizes a bridge wire across the arc gap which is exploded to start the lamp. This lamp is described in U.S. Pat. Nos. 3,256,459 and 3,274,427 and in copending Pat. application Ser. No. 554,933, filed May 19, 1966, titled "Self Starting Arc Lamp" and assigned to a common assignee.

Even though a bridge wire short arc lamp performs satisfactorily, its survival capability, arc stability, and useful like duration, when exposed to severe shock, vibration, and power overloads, has been found wanting in some respects. For example, when the lamp is constructed to withstand shock and vibration when cold (no arc), there is always danger of envelope cracking when the lamp is operating because of electrode expansion. When the lamp is constructed to withstand shock and vibration when hot, shock and vibration damage prior to reaching operating temperatures are common, and, additionally, the heat dissipation is poor, thus shortening useful life.

Even though this invention will be explained with particular reference to self-starting short arc lamps, it is to be understood that it is equally applicable to ordinary arc lamps, whether short or long arc, and whether started with a firing pulse or a bridge wire. The present invention can be employed wherever there are problems of shock, vibration, electrode alignment, or heat transfer in lamps in which electrodes are usually cantilevered into the bulb from the electrode foot.

SUMMARY OF THE INVENTION

It is therefore a primary object of the invention to provide an arc lamp having improved electrode supports and improved electrode heat dissipation for greater shock and vibration survival capacity and longer useful life of the lamp.

It is another object of the invention to provide an improved electrode support for facilitating and maintaining precision alignment of the electrodes in an arc lamp.

It is a further object of the invention to provide structure between a portion of an electrode and the inner periphery of the lamp envelope for improving the heat transfer characteristics of an arc lamp thereby providing longer life for the lamp.

It is still another object of the invention to provide a flexible or resilient or elastic or radially compressible and expandable or soft electrode support packing for an arc lamp resulting in an improved shock and vibration survival capability, a better alignment of the electrodes, and an improved heat transfer from the electrode to the envelope.

It is another object of the invention to provide a resilient electrode support for facilitating manufacture of the arc lamp to prevent breakage thereof.

It is a further object of the invention to provide a method of manufacture of an arc lamp wherein flexible resilient electrode support packing is utilized to compensate for the different coefficients of expansion of the electrodes and the envelope.

Briefly, one embodiment of an arc lamp of this invention accomplishes the stated objects by utilizing a helical coil of molybdenum wire wound around a portion of the exterior surface of each electrode for approximately eight turns. The wire coil is in the form of a helix or a spiral and has a formed interior diameter which is slightly smaller than the diameter of the electrode so that the coil is, in effect, sprung over the electrode for securement thereto. In the alternative, and for greater securement, the wire coil may also be affixed to the electrode at a single point by a spot weld or the like.

The interior surface of the envelope is ridged or grooved around the individual coils of wire to prevent dislodgement in a direction along the axis of the lamp. When the lamp is cold, there is a very small gap between the coil and either the external surface of the electrode or the internal surface of the envelope to allow for expansion. When the coil of wire becomes heated during operation of the arc lamp, the heating causes the coil of wire to expand as by winding along the longitudinal extent of the electrode. With the coil of wire being flexible or resilient, and having the ability to wind and unwind in the peripheral space between the exterior surface of the electrode and the interior surface of the envelope, the electrode is thus flexibly and resiliently supported within the envelope both when hot and cold, and the likelihood of breakage of the envelope by heating or from vibration and shock is greatly reduced. Also, the juxtaposition of the coil relative to the electrode facilitates alignment of the electrodes both during assembly of the arm lamp and while the lamp is in use. Further, the coil of wire surrounding the electrodes, being metallic and in contact with both the electrode and the envelope, improves the heat transfer from the electrode during arcing of the lamp and thus prolongs the life of the arc lamp.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in elevation of a self-starting short arc lamp constructed in accordance with this invention;

FIG. 2 is an enlarged view, partly in elevation and partly in cross section, of a portion of the arc lamp of FIG. 1 illustrating the electrode with a coil wire packing member;

FIG. 3A is a view, partly in elevation and partly in cross section, of a modification of the invention;

FIG. 3B is a view taken along lines 3B—3B of FIG. 3A;

FIG. 4A is a view, partly in elevation and partly in cross section, of a further modification of the invention;

FIG. 4B is a view taken along lines 4B—4B of FIG. 4A;

FIG. 5A is a view, partly in elevation and partly in cross section, of another modification of the invention;

FIG. 5B is a view taken along lines 5B—5B of FIG. 5A;

FIG. 6A is a view, partly in elevation and partly in cross section, of still another modification of the invention; and

FIG. 6B is a view taken along lines 6B—6B of FIG. 6A.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, in which like reference numerals designate like parts, and particularly to FIGS. 1 and 2, a short arc bridge wire lamp 10 is shown constructed in accordance with the invention. Lamp 10 includes a lamp envelope 12, usually made of quartz for well-known reasons which has typically a thermal coefficient of linear expansion of about 4.9×10^{-5} per °C. Mounted within lamp envelope 12 are a pair of electrodes 13 and 14 which respectively form the anode and cathode of lamp 10, and which are made of a refractory metal such as swaged tungsten which typically has a thermal coefficient of linear expansion of about 42×10^{-5} per °C. Electrodes 13 and 14, respectively, include a main body portion 15 and 16, foot portions 20 and 21, and arc end portions 35 and 36. Electrodes 13 and 14 may be identical, as shown in the drawings, so that either may be selected as the cathode thereby making the lamp nonpolarized. Of course, if desired, one electrode may be constructed of a larger diameter than the other to form the hotter anode as is usually done in arc lamps. However, the fact that the lamp may be made nonpolarized is an advantage in that savings are made in manufacturing cost, and the user can connect the voltage supply to the lamp without regard to polarity. If lamp 10 is of the self-starting type, a bridge wire 50 is connected across the electrode gap.

Surrounding body portions 15 and 16 of the electrodes are a pair of wires 17 and 18 which, in the preferred embodiment, are made of molybdenum having a thermal coefficient of linear expansion of about 50×10^{-5} per °C. Molybdenum wires 17 and 18 are formed into helical coils of approximately six to eight turns, and the coils, prior to being placed on the electrodes, have an internal diameter which is slightly smaller than the diameter of the electrode body portion. The coils are, in effect, sprung over the electrode body portion to hold them in place. For additional assurance, the wire coils may also be secured to the electrodes at a single location, as at 19 in FIG. 2, to allow the remainder of the coil to wind and unwind over the exterior surface of the electrode body portions, as will be described hereinafter.

Electrodes 13 and 14 are primarily supported, in cantilever fashion, within envelope 12 by shrinking the portion of envelope 12 coextensive with electrode feet 20 and 21 about the electrode feet. Wire coils 17 and 18, as will become clearer from the ensuing description, supplement the cantilever support and further secure the electrodes against longitudinal and lateral displacement when the envelope portion coextensive with the wire coils is shrunk about the wire coils.

This shrinking is accomplished as an additional step in the manufacture of the lamp after the envelope has been shrunk around electrode feet 20 and 21 and sealed over the ribbons. More particularly, the arc lamp, which is under negative pressure for well-known manufacturing reasons, is heated uniformly to a temperature which corresponds to its operating temperature which is between 1,400 and 1,500° C. This causes the electrodes, the wire coils, and the envelope to expand in accordance with their respective thermal coefficients of linear expansion and assure their sizes at operating conditions.

Thereafter, the portion of envelope 12 coextensive with wire coils 17 and 18 is heated to about 1,650° C. which is close to the softening point of the quartz. Because of the negative pressure inside envelope 12, the heated portion, now softened, moves inwardly under the negative pressure until it comes into contact with wire coils 17 and 18. This corresponds to a hard shrink of the envelope upon the wire coils. The degree of penetration of envelope 20 into the spaces between the coils is carefully controlled by the flame so that good-sized corrugations or grooves 22 are formed in the interior surface of the envelope. After a desirable degree of penetration is obtained, the arc lamp envelope is allowed to cool which causes electrodes 13 and 14, coils 17 and 18, and envelope 12 to contract. Since the thermal coefficient of linear expansion of the quartz is approximately 10 times less than that of the tungsten electrode, or the molybdenum wire, it is readily seen that coils 17 and 18 will shrink away from the quartz envelope and thereby change the hard shrink support to a soft support. For a wire coil, which is typically constructed of 0.015-inch diameter wire, and which surrounds an electrode having a diameter of about one-eighth of an inch, it has been found that the shrink-away is about 0.001 inch.

It is to be noted at this point that whenever the arc lamp is at its operating temperature, a hard shrink condition exists between the envelope, the wire coils and the electrodes. This condition is not dangerous to the integrity of the envelope since the envelope was shrunk on the coil-electrode combination at this temperature and the forces, due to expansion of the electrodes, are not in excess of those which caused the envelope to shrink about the electrode in the first place during manufacture. Accordingly, during operating condition, there is firm lateral and longitudinal support of the electrodes and good thermal contact from the electrodes to the envelope which is due to the hard-shrunk condition.

When the arc lamp is cold, wire coils 17 and 18 become elastic springs which resiliently support the electrodes within the envelope. As wire coils 17 and 18 contract during cooling, they become shorter and wind up upon the electrode body using grooves 22 as guides which they threadably engage. This is best seen in FIG. 2 where wire end 19 may be secured to the electrode, and wire end 19*a* is movable through a distance D during winding and unwinding. When the lamp 10 is cold, it can be said that the electrodes are flexibly or resiliently supported by the coils of wire within the envelope. Also, it can be seen that the coils of wires 17 and 18 help maintain the electrodes 13 and 14 in alignment both during assembly and during use and, most importantly, if the coils of wires are firmly secured to their respective electrodes, then grooves 22 secure the electrodes against axial displacement.

Foot 20 of electrode 13 is connected to a pair of conductive ribbons 25 and 26 by spot welds 10 tantalum or molybdenum wire (typically 0.006 inch) tabs 27 and 28, one on each side of electrode foot 20 as shown in FIG. 1. Ribbon 25 is typically made of molybdenum having a width of one-eighth of an inch and a thickness of 0.7 mils. The other end of ribbon 25 is similarly connected to a terminal lug 30 to which a flexible lead 31 is affixed. The advantage of having a pair of ribbons 25 and 26 at the electrode foot is that a layer of metal ribbon is thus superimposed between the electrode foot and the quartz envelope. Such superimposed layer of metal ribbon helps prevent breakage as the quartz envelope is shrunk in relation to the interior lamp assembly just described.

A similar metal ribbon construction is connected to the other electrode and to a terminal lug 32 to which flexible lead 33 is attached. This lamp construction is generally known as a "ribbon seal" lamp since the seal between the lamp interior and the outside is formed around the ribbons. It is to be understood that the present invention is equally applicable to "rod seal" lamps in which the ribbons are replaced by rods and where a seal is formed around the rods.

Thus, the components of a short arc bridge wire lamp have been described wherein a flexible resilient electrode support feature has been described in conjunction with coils of wire 17 and 18 surrounding body portions 15 and 16 of electrodes 13 and 14.

Before describing a number of modifications of the electrode support shown in FIGS. 1 and 2, it may be helpful to delineate the general support requirements which are met by the wire coils. As a consequence of the cantilever support of

the electrodes in the lamp envelope, the basic survival capability of the arc lamp to severe shock and vibration is low. Shrinking the envelope upon the body portion of the electrode when the same is below operating temperature is not possible because the electrode has a much greater thermal coefficient of linear expansion than the envelope and would, therefore, crack the envelope when expanding during arc operation. Shrinking the envelope directly upon the body portion of the electrode when the same is at operating temperature is likewise not the answer because, when the lamp is cold, the electrode is not securely supported against lateral and longitudinal displacement. Accordingly, what is required is a soft support when the lamp is cold and a hard support when the lamp is hot, the hard support corresponding to shrinking the envelope upon the electrode.

In accordance with this invention, a cylindrical space **51** is provided between the exterior surface of the main body of the electrode and the corresponding interior surface of the envelope. Disposed in this space is a packing with certain properties. The packing substantially fills the cylindrical space to thereby support the electrode within the envelope at any electrode temperature. The packing provides a thermal path across the space to allow for the dissipation of heat. Finally, the packing not only provides lateral support by filling the space, but may also provide longitudinal support by affixing the packing to the electrode and shaping the envelope as is obtained by the coils of wire described in connection with FIGS. **1** and **2** which are secured to the electrodes and threaded in grooves **22**.

The above characteristics of the packing are provided by a metallic packing which is radially compressible and expandable to accommodate itself to the variation of the radial gap dimensions due to the enormously different thermal coefficient of linear expansion. The coil springs meet these requirements since they are elastic and in contact with the electrode and the envelope when cold or hot. When hot, the clearance disappears and good support and thermal conductivity by a hard-shrunk fit is assured. With these basic concepts in mind, it will not be understood that a large number of modifications of the packing are possible without departing from the spirit of the present invention.

FIGS. **3A** and **3B** disclose a modification of the invention wherein the packing member about which the envelope **12** is shrunk takes the form of a metallic refractory ribbon spring **52** which is wound several times around body portions **15** of electrode **13**. The interior end **53** of the metallic ribbon spring **52** is secured to the electrode as by spot welding or the like, while the other end **54** is allowed to remain free. Thus, the coil of metallic ribbon **52** is free to wind or unwind relative to the body portion of the electrode and within the deformed position of the envelope shrunk thereabout as the ribbon expands and contracts as a result of ambient conditions. The metallic ribbon **52** thereby resiliently supports the electrode **13** to withstand vibration and shock by the cushioning action of the wrapped ribbon and the freedom of expansion and contraction of the ribbon **52**. Furthermore, the ribbon engages the edge **49** of the annular groove formed in the envelope **12** as it was shrunk thereabout to provide the desired longitudinal integrity. The metallic ribbon **52** wound around the body portion **15** also affords the advantages of improved heat transfer from the electrode to the envelope, and aids in maintaining the electrodes in alignment.

FIGS. **4A** and **4B** disclose a further modification of the invention wherein the packing member takes the form of a corrugated cylinder **60** having ridges **61** in contact with the interior surface of envelope **12** and trough **62** in contact with body portion **15** of electrode **13**. To secure packing member **60** to electrode **13**, portion **15** may be threaded or a portion such as **62** may be spotwelded to electrode **13**. Likewise, for longitudinal integrity, envelope **12** may be shrunk over corrugated cylinder **60** in a manner similar to that described in connection with shrinking the envelopes over the coils of wire. Elasticity, or radial compressibility, provides the necessary adjustment for the variation in the gap distance, and thereby supports electrode **13** either in the hot or cold condition. Further, good thermal transfer characteristics are associated with a corrugated cylinder **60**.

FIGS. **5 A** and **5B** show a still further modification of the invention wherein the packing member takes the form of a lengthwise corrugated cylinder **70** having crest at **71** for engaging the interior surface of envelop **12** and valley **72** for engaging body portion **15** of electrode **13**. FIGS. **6A** and **6B** disclose yet another modification of the invention wherein the packing member takes the form of a cylinder **80** which includes a number of outwardly projecting spaces **81** for engaging the interior surface of envelope **12**. The interior surface **82** of cylinder **80** may be shrunk over body portion **15** of electrode **13**.

In the embodiments shown in FIGS. **3A**, **4A**, **5A**, and **6A**, longitudinal support may be provided by shrinking envelope **12** over the points of contact with the packing member. Lateral stability is usually provided by the two point contact provided by different surfaces of the packing member with the interior envelope surface and exterior electrode surface.

Thus, an arc lamp having flexible resilient electrode supports has been described wherein damage from vibration and shock is reduced, heat transfer is improved, and alignment of the electrodes is facilitated and maintained, thereby improving its overall operation of the arc lamp and its longevity.

While the above-detailed description has shown, described, and pointed out the fundamental novel features of the invention as applied to various embodiments, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In the method of constructing an arc lamp having a pair of cantilever supported, spaced-apart, refractory electrodes disposed within an envelope, the improvement comprising the steps of:

winding a coil of refractory wire around a portion of at least one of said electrodes prior to placing the same in the envelope, the wire-wound portion being disposed on the side of the cantilevered portion adjacent the arc end of the electrode;

heating the sealed envelope, with the electrodes in place and the envelope under negative pressure, to the normal arc lamp operating temperature; and

shrinking the portion of the envelope opposite said coil of wire without wetting on said coil or wire for lateral support of the electrode.

2. The method in accordance with claim **1** which includes the additional step of forming a spiral groove in the interior surface of the portion of the envelope being shrunk upon the coil of wire to partially accommodate the coil of wire for longitudinal support.

3. The method of constructing an arc lamp having a pair of cantilevered, spaced-apart electrodes disposed within an envelope, said method comprising the steps of:

winding a coil of refractory wire around the normally unsupported portions of each of said electrodes prior to placing the electrodes within the envelope;

sealing the envelope under a reduced internal pressure and hard-shrinking the envelope about the electrodes feed adjacent the normally unsupported portion of the electrode on the side opposite the arc end to provide the cantilevered support;

heating the envelope, electrodes and coils of wire to the normal arc lamp operating temperature with a negative pressure inside the envelope to shrink the envelope without wetting about said coils of wire to provide electrode body support at the normal arc lamp operating temperature.

4. A method in accordance with claim 3 in which the step of shrinking the envelope about the electrode feed follows the step of shrinking the envelope about the coils of wire.

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