# United States Patent

**Clarke et al.**

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[54] **DISCHARGE LAMPS HAVING IMPROVED THERMIONIC CATHODES**


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[52] **U.S. Cl.**.....**313/346 R,** 313/184, 313/356

[51] **Int. Cl.**.....**H01j 1/14,** H01j 19/06

[58] **Field of Search**.....313/356, 346, 184



[56] **References Cited**

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[57] **ABSTRACT**

A thermionic cathode for discharge lamps is a two part structure consisting of a wire stem bearing a cup at its end, the cup being a receptacle for an electron-emitting composition and ensuring that electrons can only issue from the mouth of the cup and not by passage through the side of the cup. In one form, a foil is rolled around the end region of the stem, the rolled foil projecting beyond the end of the stem and thereby forming the cup. Instead of foil, a welded-coil may be used in a similar way to define the cup.


**3 Claims, 3 Drawing Figures**

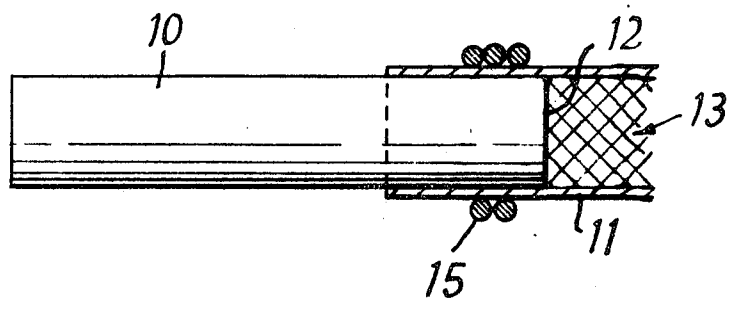


FIG. 1.

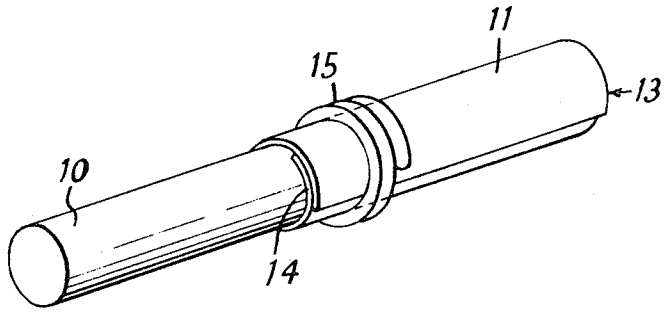



FIG. 2.

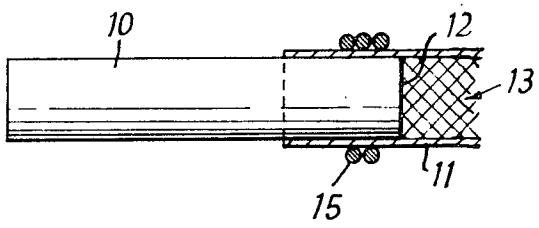
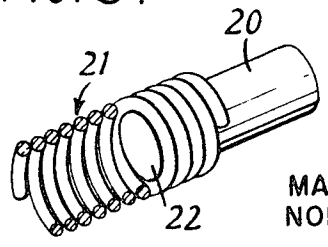



FIG. 3.




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# DISCHARGE LAMPS HAVING IMPROVED THERMIONIC CATHODES

The present invention relates to discharge lamps having improved thermionic cathodes.

According to the present invention there is provided a discharge lamp including a thermionic cathode which comprises a refractory metal stem and a refractory metal tubular member which is secured to one end of the stem, the tubular member extending beyond the end of the stem to form a cup and an electron-emitter composition being contained in the cup. The said composition may include a refractory metal, a lanthanide metal or thorium and a further metal which is at least partially soluble in the lanthanide or thorium and whose alloy therewith is capable of wetting the refractory metal in the said composition.

The particular metallic elements used can be any of those described in British Patent Specification No. 1,137,124 and in a paper published in the British Journal of Applied Physics, 1967, 18, 627. Thus the refractory metal forming the stem and sleeve and the refractory metal of the said composition may be tungsten, tantalum or molybdenum, although tungsten is preferred.

The said further metal should have a low vapor pressure at the operating temperature of the lamp, which typically may be in the range 1,400° to 1,800°C. The further metal can be an element in the first transition series, that is in the fourth period of the periodic classification of elements, and may be any of the elements having atomic numbers 22 to 28. Alternatively it can be a precious metal selected from the transition series of the fifth and sixth periods. Suitable elements are those having atomic numbers 44 to 46 or 76 to 78. Moreover, instead of being a Group VIII element, the further metal could be a lanthanide if the composition includes thorium; if the composition includes a lanthanide instead of thorium, then the further metal could be another metal in the lanthanide series. Optimum results are however obtained if the further metal is a Group IVa metal, that is titanium, zirconium or hafnium.

The said electron-emitter composition should contain 85 to 95 percent of refractory metal, up to several percent of further metal with the balance being the said lanthanide or thorium. A satisfactory composition is 90% W, 9.5%Th and 0.5%Zr. Other compositions which may be used are described in the two above-mentioned references.

The said electron-emitting composition can be introduced by pressing dry powder into the cup formed by the end of the stem and the sleeve, and the cup need not be completely filled therewith. It may be sufficient to provide the inner surfaces of the sleeve with a coating of the said composition. After applying the coating, the sleeve is heated to sinter the said composition coating thereto.

In one embodiment, the tubular member is a refractory metal foil which is wound or wrapped around the stem adjacent one of its ends. The tubular member thus forms a sleeve around the stem and projects from the end thereof to form a hollow cylindrical cup. The foil should be wrapped upon itself so that in operation, emitted electrons and any evaporated metal atoms can only pass through the mouth of the cup and cannot escape transversely through the wall of the cup. This



can be achieved by making the foil of such dimensions that approximately 1 1/2 turns or more can be wound around the stem. The foil may be clamped to the end of the stem by an embracing coil of wire, which also should be of refractory metal such as tungsten.

Embodiments of the invention will now be described in more detail by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a thermionic electrode,

FIG. 2 is a side elevation. partly in section of the electrode shown in FIG. 1, and

FIG. 3 is a perspective view, partly cut away of another form of thermionic cathode.

A thermionic cathode for use in a discharge lamp is shown in FIG. 1 and 2 of the drawings and has a refractory metal supporting rod or cylindrical stem **10**, for example in the form of a wire, the refractory metal being tungsten. A tubular member **11**, likewise of tungsten, is secured to the stem **10** adjacent the end **12** thereof and forms a cup **13**. The tubular member can be regarded as a sleeve fitted to the end of the stem so as to project beyond the said end. As shown, the member **11** is formed by a refractory metal sheet or foil, of tungsten, which is wrapped around the stem. The width of the foil is greater than the circumference of the stem **10**. Thus there is an overlapping portion **14** of the foil which ensures that when the foil is wound or wrapped around the stem **10** it also wraps around upon itself. The width of the foil is such that, it can be wrapped approximately 1½ times around the stem **10**. As an example of the dimensions involved, the tungsten stem may be 0.050 inch diameter and the foil may be 0.001 inch in thickness and of the order of 0.25 inch in width. The foil is secured or clamped to the end of the stem **10** by a tight encircling coil of wire **15**. The wire **15** is a length of tungsten wire.

The cup **13** contains an electron-emitter composition consisting of 90% W, 9.5% Th and 0.5% Zr. After introducing the composition into the cup, for example by pressing the dry, powdered composition therein, the assembly is vacuum fired or annealed at a temperature in excess of 1,200°C. A precaution to be noted is that if a different composition is utilized, namely one containing lanthanum or cerium, then care will be necessary to exclude air whilst preparing the composition and before vacuum annealing. The reason for this precaution is that lanthanum and cerium are spontaneously inflammable when finely powdered.

The composition need not completely fill the cup **13**. It could in fact be a surface coating on the inner surface of the foil, and such a coating could be applied to the foil before winding or wrapping it around the stem **10**. The composition could be applied to the foil by one of the methods described in the above-mentioned references and then sintered thereon by vacuum annealing at a temperature in excess of 1,200 °C. Steps must be taken to ensure that the overlapping portion **14** of the foil is free from the surface coating.

The embodiment illustrated in FIG. 3 likewise has a refractory tubular member **21** forming a sleeve around the stem **20**. The member **21** projects away from the end **22** of the stem **20** to form a cup for the electron-emitter composition. The tubular member **21** in this case is in the form of a helically-wound wire whose

turns contact one another. At least those turns defining the cup are fuzed together. By so fuzing the turns, a tubular member **21** having a continuous wall is produced. The turns may be fuzed together by arc welding or preferably by electron-beam welding. The tubular member **21** can be secured to the stem **20** by welding, or simply by being a tight fit thereon.

The type of discharge lamp with which the cathode structures described above are particularly suited is the high pressure sodium or mercury lamp. Unlike conventional cathodes for discharge lamps which embody alkaline earth oxides as emitters, the present cathode structures are substantially insensitive to atmospheric moisture and oxidation. The conventional cathodes are very sensitive to becoming "poisoned" upon exposure to the atmosphere and are rendered ineffective thereby. They require most carefully controlled processing and handling than the present cathode structure. Furthermore, the cathodes described above enables efficient electron emission to be obtained at lower temperatures than is possible with cathodes consisting of plain metal emitters. For example, a pure tungsten cathode wire has to be heated to temperatures of the order of 1,000°C higher than the present cathode for adequate emission to be obtained.

The cathode structures described, in common with shielded types of cathode, possesses a further advantage over conventional open coil structures and that is that blackening of the envelope of the discharge lamp is substantially eliminated. Blackening is prevented because the continuous wall of the cup **13** does not allow evaporated constituents of the electron-emitter composition to pass transversely out of the cup and reach the envelope of the discharge lamp.

It will be appreciated that an electrodes constructed as described above can be manufactured with ease. A



thermionic electrode would be extremely difficult to manufacture accurately by boring a hole in a refractory metal wire or stem because of the small overall dimensions normally required for such electrodes.

We claim:

**1.** A discharge lamp having an improved thermionic cathode, said cathode comprising: a refractory metal stem; a refractory metal tubular member secured on one end of said stem, said tubular member extending beyond the end of said stem to form a continuous walled cup; an electron-emitter composition contained within said cup; the extensional direction of said cup being substantially longitudinal with said discharge lamp, so that evaporated constituents of said electron-emitter composition do not deposit on the envelope of said discharge lamp during normal lamp operation; said electron-emitting composition containing:

i. a refractory metal selected from the group consisting of tungsten, molybdenum and tantalum;

ii. a second metal selected from the lanthanide series of elements and thorium in Group IIIa of the periodic classification, and

iii. a third metal that is at least partly soluble in the second metal to form an alloy therewith, said alloy being capable of wetting said refractory metal in said composition.

**2.** The combination according to claim **1**, wherein said tubular member is a helically-wound wire-coil, turns of said coil contacting one another and at least those turns thereof which extend beyond the end of said stem to define said cup being welded together thereby forming a continuous wall.

**3.** The combination according to claim **1**, wherein a foil wrapped around the end of said stem forms said tubular member.

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