March 10, 1970 L. C. EMERICK 3,500,454

INSULATOR HEATER COATING FOR HEATER-CATHODE ASSEMBLY

Filed Nov. 16, 1967 2 Sheets-Sheet 1

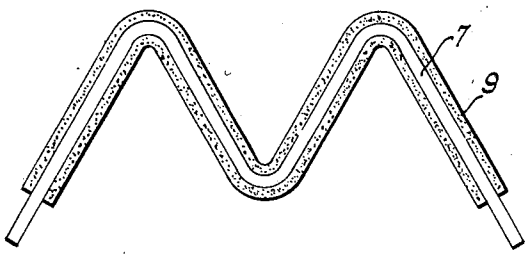


Fig. 1

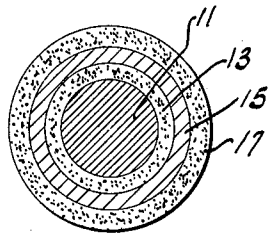


Fig. 2

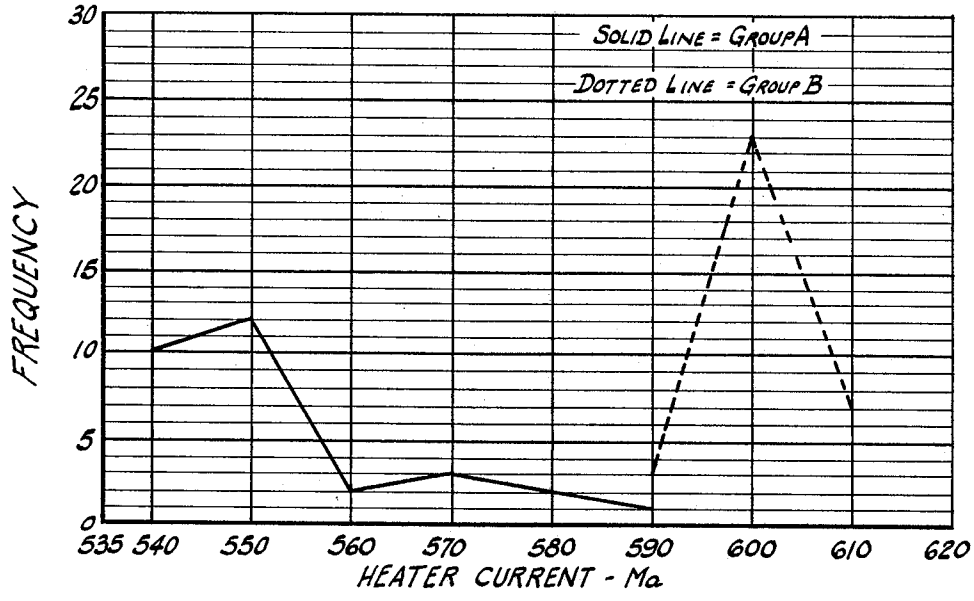


Fig. 3

INVENTOR.
LLOYD C. EMERICK

BY

Robert E. Stauner
ATTORNEY

March 10, 1970 L. C. EMERICK 3,500,454

INSULATOR HEATER COATING FOR HEATER-CATHODE ASSEMBLY

Filed Nov. 16, 1967 2 Sheets-Sheet 2

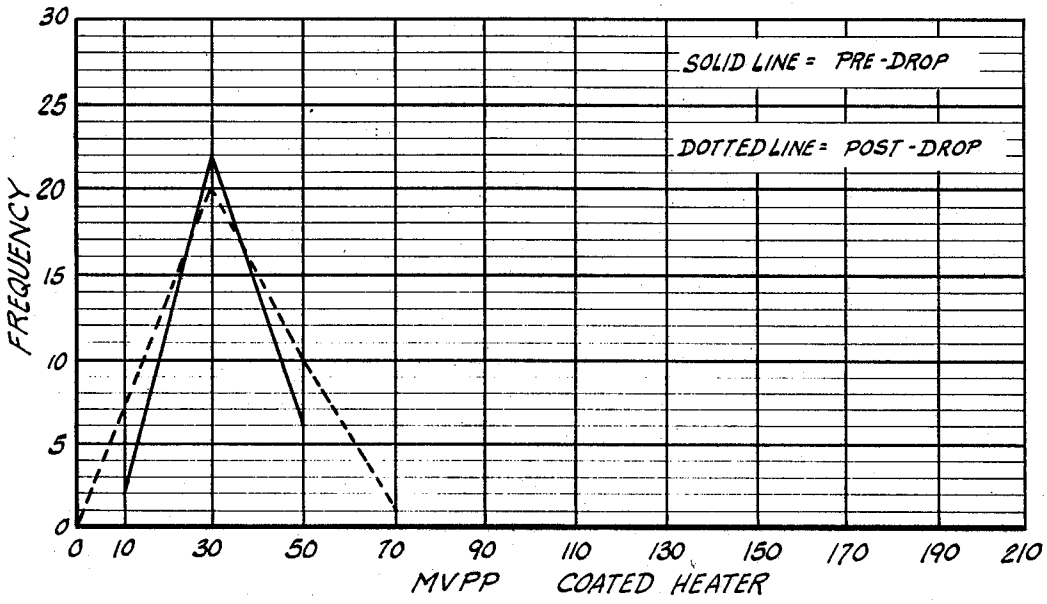


Fig. 4

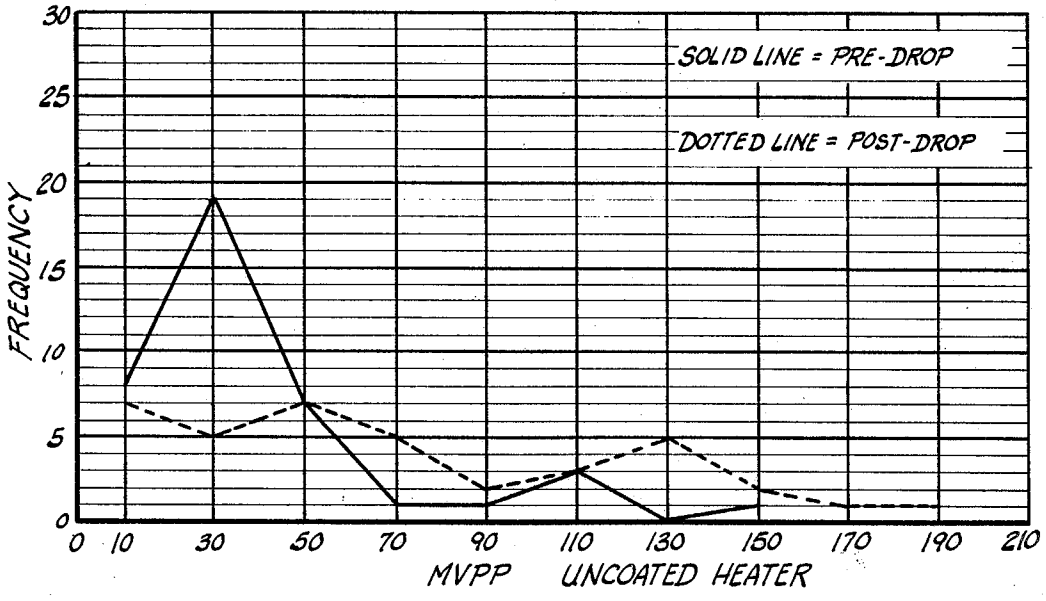


Fig. 5

INVENTOR.
LLOYD C. EMERICK

BY

Robert E. Stransser
ATTORNEY

United States Patent Office 3,500,454
Patented Mar. 10, 1970

3,500,454

INSULATOR HEATER COATING FOR HEATER-CATHODE ASSEMBLY

Lloyd C. Emerick, West Burlington, Iowa, assignor to Sylvania Electric Products Inc., a corporation of Delaware

Filed Nov. 16, 1967, Ser. No. 683,629
Int. Cl. H01j 1/24, 19/18
U.S. Cl. 313—340 6 Claims

ABSTRACT OF THE DISCLOSURE

The heater of a heater-cathode assembly for an indirectly-heated electron discharge device includes a wire core, a first coating of electrical insulating material, a second coating of relatively high thermal emissivity material, and a third coating of electrical insulating material whereby the third coating tends to reduce sublimation of the second coating under adverse temperature environments occurring during the fabrication of electron discharge devices and also during normal energization of the device under application conditions.

BACKGROUND OF THE INVENTION

It has long been known that the heater of an indirectly-heated cathode assembly of an electron discharge device normally includes a wire core of a refractory material such as tungsten surrounded by an insulator coating. The most common insulator coating material is aluminum oxide which is substantially white in color and tends to increase in whiteness as the purity of the material is increased.

However, electron discharge devices require materials of relatively high purity. Unfortunately, increased purity of aluminum oxide insulating material results in increased whiteness and an accompanying undesired decreased heat radiating capability.

The prior art suggests a number of techniques for alleviating the above-mentioned undesired decrease in heat radiating capability with increased purity of the aluminum oxide insulator coating. For example, one known prior art technique proposes the inclusion of tungsten metal particles in an aluminum oxide coating to provide a metallic tungsten particle-aluminum oxide mixture or a so-called "dark heater" having improved heat radiating capability. Another similar prior art technique suggests a heater which includes a tungsten wire core, an insulating layer of aluminum oxide, and a second layer which includes a mixture of aluminum oxide and another material such as tungsten metal particles, graphite, or lampblack. Again, a so-called "dark heater" having improved heat radiating capability is provided.

However, even though the above-mentioned so-called "dark heater" techniques have received widespread acceptance and provided a measurable amount of improved heater capability, it has been discovered that a problem area remains. More specifically, it has been found that the dark layer tends to sublime at the relatively high processing temperatures, about 2000° C., to which the heater of an electron discharge device is subjected during the exhaust cycle of the fabrication process. As a result of this dark layer sublimation, it has been found that supposedly similar discharge devices tend to be undesirably unreliable because of the relatively wide variation in such electrical characteristics as heater current, heater-cathode leakage, and particularly dynamic heater-cathode leakage.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide an enhanced heater for the heater-cathode assembly of an indirectly-heated electron discharge device. Another object of the invention is to provide a heater for an electron discharge device having improved reliability and heat radiating capability. A further object of the invention is to provide an electron discharge device heater having improved uniformity and heat radiating capacity even though subjected to adverse temperature environments during fabrication of the discharge device.

These and other objects, advantages and capabilities are achieved in one aspect of the invention by an electron discharge device heater which includes a wire core with a first coating of insulating material surrounding the wire core, a second coating of relatively high thermal emissivity material affixed to and surrounding the first coating, and a third coating of insulating material affixed to and surrounding the second coating.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a typical heater configuration suitable for use in the heater-cathode assembly of an indirectly-heated electron discharge device;

FIG. 2 illustrates, in cross-sectional view, a heater embodying one aspect of the invention;

FIG. 3 is a frequency polygon comparing heat current of discharge devices employing one embodiment of the invention and discharge devices wherein the invention has not been employed;

FIG. 4 is a frequency polygon of dynamic heater-cathode leakage taken from electron discharge devices employing heaters utilizing one embodiment of the invention; and

FIG. 5 is a frequency polygon of dynamic heater-cathode leakage taken from electron discharge devices employing similar heaters not utilizing the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

To facilitate a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the accompanying drawings.

Referring to the drawings, FIG. 1 illustrates a typical heater configuration suitable for insertion within a cathode sleeve of a material such as nickel to provide an indirectly-heated heater-cathode assembly. Normally, the heater includes a wire core **7** of a refracting material such as tungsten and a layer **9** of electrical insulating material such as aluminum oxide surrounding and affixed to at least a portion of the wire core **7**.

As a specific illustration of one embodiment of the invention, reference is made to the cross-sectional view of FIG. 2. Therein, the heater includes a wire core **11**, a first coating **13** of electrical insulating material, a second coating **15** having a relatively high thermal emissive capability, and a third coating **17** of electrical insulating material.

The wire core **11** is preferably of a refractory material such as tungsten with the first coating **13** surrounding and affixed to at least a major portion thereof. This first coating **13** is an electrical insulating material such as the oxides and silicates of such metals as beryllium and titanium although aluminum oxide is, by far, the preferred and most commonly used material.

Surrounding and affixed to the first coating **13** is a second coating **15** of a material having a relatively high thermal emissivity. Preferably, the second coating **15** is a mixture of aluminum oxide and tungsten metal particles

although the tungsten metal particles may be replaced by such materials as graphite and lampblack.

A third coating **17** of electrical insulating material surrounds and is affixed to the second coating **15**. Preferably, the third coating **17** is aluminum oxide as mentioned above in regard to the first coating **13** although the oxides and silicates of such metals as beryllium and titanium are also applicable and appropriate materials for the third coating **17**. Also, the third coating **17** is relatively porous having a thickness in the range of about 0.0005 to 0.0015 inch. Even though this third coating **17** is relatively thin and porous, it has been found that sublimation of the second coating **15** under adverse environmental conditions of temperature is inhibited thereby while the desired relatively high electrical insulation and thermal emissivity capabilities of the heater are maintained.

To illustrate the desirable effects of the above-described embodiment, two groups of heaters were fabricated in substantially identical manner except that a third coating **17** of aluminum oxide was applied to only one of the groups. Thereafter, the heaters were inserted into substantially identical electron discharge device structures, processed under substantially identical conditions, and tested for heater current on the same apparatus under substantially identical conditions.

As can readily be seen on the frequency polygon of FIG. 3, the control group, group A, which included the first and second coating **13** and **15** respectively but not the third coating **17** has a relatively wide range of heater current when compared with the test group, group B, which includes not only the first and second coatings **13** and **15** but also the third coating **17**. Also, it may be noted that the test group, group B, which includes the third coating **17** has a much higher average value of heater current which is indicative of reduced sublimation of the second layer **15** and enhanced thermal radiating capability.

As a further illustration of the advantageous results obtainable with the above-described embodiment, reference is made to the comparative illustrations of FIGS. 4 and 5. FIGS. 4 and 5 illustrate heater-cathode leakage readings in millivolts peak-to-peak under dynamic operational conditions both before and after a drop test standard in the industry. FIG. 4 shows the frequency and range of heater-cathode leakage for a group of electron discharge devices having a heater therein which includes the previously-described first, second and third coatings **13**, **15** and **17** respectively, while FIG. 5 shows the frequency and range of heater-cathode leakage for a substantially identical group of electron discharge devices having a heater therein which includes the first and second coatings **13** and **15** but not the third coating **17**.

Since the heaters and electron discharge devices were fabricated and tested under conditions as nearly identical as possible, with the exception of the added third coating **17** to the group of FIG. 4, the enhanced uniformity provided by the added third coating **17** is readily discerned from the figures. Also, the reduced range of heater-cathode leakage for the group of FIG. 4 having the heater which includes the third coating **17** as compared with the group of FIG. 5 wherein the heaters do not include the third coating **17**, is readily observable.

Thus, there has been provided a unique heater suitable for use in indirectly-heated heater-cathode assemblies for electron discharge devices. The improved heater not only reduces the range and level of heater current indicating reduced sublimation and enhanced thermal radiating capability but also provides a desired reduced range of dynamic heater-cathode leakage both prior to and after drop testing.

While there has been shown and described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A heater suitable for an indirectly-heated electron discharge device comprising:
- a wire core;
- a first coating of insulating material affixed to and covering at least a portion of said wire core;
- a second coating of relatively high thermal emissivity material affixed to and surrounding at least a portion of said insulating material coating; and
- a third coating of insulating material affixed to and covering at least a portion of said second coating.

2. The heater of claim **1** wherein said insulating material of said first and third coating is aluminum oxide.

3. The heater of claim **1** wherein said relatively high thermal emissivity material is a mixture of an insulating material and a material selected from the group consisting of graphite, lampblack, and metallic tungsten particles.

4. The heater of claim **1** wherein said relatively high thermal emissivity material is a mixture of aluminum oxide and metallic tungsten particles.

5. The heater of claim **1** wherein said first and third coatings are aluminum oxide and said second coating is a mixture of aluminum oxide and metallic tungsten particles.

6. A heater suitable for an indirectly heated electron discharge device comprising:
- a wire core;
- a first coating of insulating material affixed to and covering at least a portion of said wire core;
- a second coating of relatively high thermal emissivity material affixed to and surrounding at least a portion of said insulating material coating; and
- a third coating of insulating material affixed to and covering at least a portion of said second coating, said third coating having a thickness in the range of about 0.0005 to 0.0015 inch.

References Cited

UNITED STATES PATENTS

792,001	6/1905	Callan	313—337 X
1,618,499	2/1927	White	313—337 X
1,954,474	4/1934	Esde et al.	313—340
2,677,782	5/1954	Gehrke et al.	313—340
2,749,470	6/1956	Billings et al.	313—340
3,161,540	12/1964	Kingsley et al.	313—337
3,195,004	7/1965	Hassett	313—340
3,262,814	7/1966	Provisor	313—337 X
3,305,405	2/1967	Jamieson	313—340 X
3,328,201	6/1967	Scheible	313—340 X

FOREIGN PATENTS

1,090,774	10/1960	Germany.

JOHN W. HUCKERT, Primary Examiner

A. J. JAMES, Assistant Examiner

U.S. Cl. X.R.

313—270, 311, 337