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COLD CATHODE DISCHARGE DEVICE

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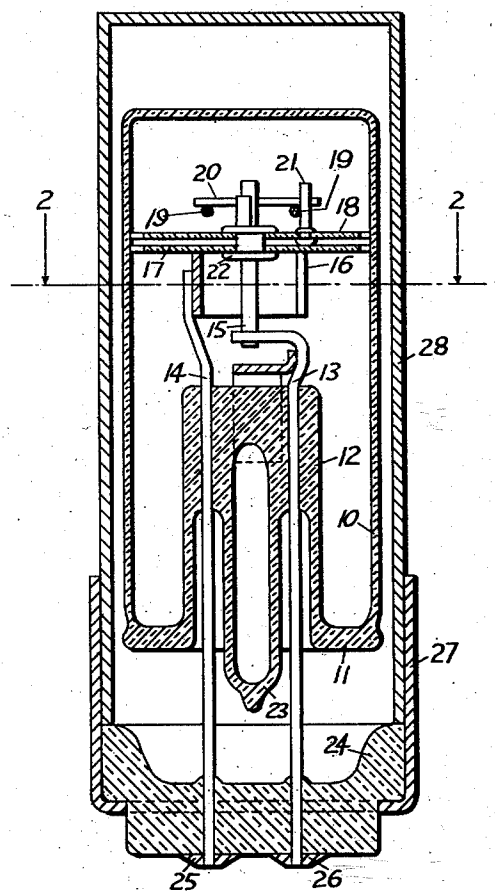


FIG. 1

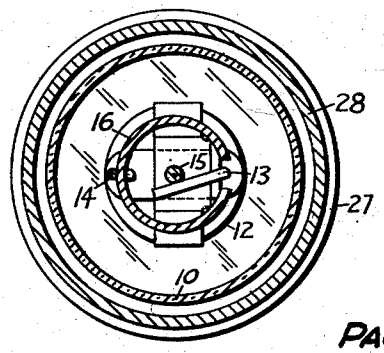


FIG. 2

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COLD CATHODE DISCHARGE DEVICE

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8 Claims. (Cl. 316—26)

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This invention relates to gaseous-discharge devices and more particularly to cold cathode gaseous-discharge devices of the type which may be used as voltage regulators.

In voltage regulators of the type generally used, a cold cathode gaseous-discharge device is utilized, the characteristic of the cathode being such that the current density at the cathode and hence the cathode drop remain substantially constant for wide variations of current flow through the device. The constant current density is accomplished by making the cathode surface substantially homogeneous such that the cathode spot increases or decreases in the area in proportion to the current drawn.

Previously, attempts to use molybdenum as the cathode material have proved unsatisfactory since the surface of the molybdenum becomes contaminated by the gas or due to contamination of the metal itself whereby the cathode surface is rendered non-homogeneous. As a result, the cathode spot during discharge tends to remain constant in size or the area thereof varies as a non-linear function of the current, thereby varying the cathode fall with current variations, thus making the device useless as a voltage regulator.

This invention discloses a method of processing a molybdenum cathode discharge device which will cause the device to be operative as a voltage regulator over a long period of time.

Briefly, the invention comprises positioning the electrode elements in the device, filling the device with a gaseous medium, and sealing the device. Following this, a glow discharge is produced between the cathode and another element of the device, for example, the anode, said discharge being of sufficient magnitude to cause substantial sputtering of the cathode. The sputtered particles become attached to the other elements of the tube, for example, the anode and support structures, as well as portions of the tube envelope. In addition, some particles return to the cathode. The result is that the sputtered particles react with the gas to remove any contaminating material therefrom. Continuation of the sputtering process long enough will produce a clean gaseous medium and a clean cathode surface. On this surface, the current density of the glow spot will remain substantially constant with the area of the spot increasing or decreasing in proportion to the current flow. Such a device once properly processed will retain its voltage regulating characteristic for an extremely long time, for example, in excess of five thousand hours.

In addition, if desired, a getter may be utilized to initially clean the gas prior to the sputtering process.

Other and further advantages of this invention will be apparent as the description thereof progresses, reference being had to the accompanying drawing, wherein:

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Fig. 1 illustrates a longitudinal, cross-sectional view of an electron-discharge device constructed and processed in accordance with the invention; and

Fig. 2 illustrates a transverse, cross-sectional view of the device shown in Fig. 1 taken along line 2—2 of Fig. 1.

Referring now to Figs. 1 and 2 of the drawing, there is shown a gaseous-discharge device comprising a glass envelope 10 having a base section 11. Extending upwardly from base section 11 is a glass press 12 through which extends a pair of lead-in members 13 and 14. Lead-in member 13 is attached to a rod 15 which constitutes the anode of the device, said anode being substantially coaxial with envelope 10 and may be made, for example, of nickel. Lead-in member 14 has attached thereto a substantially cylindrical member 16 which surrounds the anode member 15, member 16 comprising the cathode and being made in accordance with this invention of molybdenum.

Positioned above cathode member 16 is a mica spacer member 17 which engages anode rod 15 and the sides of envelope 10, thereby positioning anode rod 15 coaxially with envelope 10 and coaxially with cathode 16. A second mica spacer 18 is positioned above spacer 17 and supports a getter structure comprising a U-shaped support member 19 to which is attached a bar of getter material 20 which may be flashed, for example, by induction heating. Member 19 is supported by a pair of uprights 21 attached to mica spacer 18 and the entire getter assembly on mica spacer 18 is rigidly positioned above mica spacer 17 by a metallic grommet 22 extending through spacers 17 and 18 and surrounding the upper end of anode rod 15 and rigidly engaging said anode.

An exhaust tube 23 extends downwardly from press 12 whereby the tube may be exhausted and filled with the discharge medium following which the end of tube 23 is sealed. Leads 13 and 14 extend downwardly through a base 24 which may be, for example, ceramic or glass and terminate in contacts 25 and 26, respectively. Base 24 is supported in a metallic holder 27 which is attached to a metallic shield 28 surrounding envelope 10.

The tube elements are first assembled and inserted in envelope 10. The envelope 10 is then evacuated and refilled with the desired gas mixture which comprises, for example, neon and argon in the proportion of ninety-nine per cent neon and one percent argon. It has been found that a desired pressure for the gaseous medium is on the order of seven centimeters of mercury.

The getter assembly 19 is then flashed, for example, by induction heating to cause a preliminary clean-up of the gaseous filling. If desired, this getter operation may be eliminated by the use of a suitably pure gaseous filling and adequate outgasing of the tube structure prior

to filling with the gas. A discharge is now produced between the cathode 16 and the anode 15 sufficient to produce sputtering of the cathode. A suitable voltage for this comprises two hundred and twenty volts A. C. R. M. S. with the negative portion of the cycle eliminated, for example, by clipping.

The current through the device is then adjusted by adjustment of a suitable load resistor in series with the discharge device and the voltage source to an average current on the order of forty milliamperes. For this condition, a peak current as high as one hundred and sixty milliamperes will be produced. The particular currents cited herein will vary for the particular dimensions of the cathode surface, and as disclosed herein are for a cathode utilized in a miniature voltage regulator.

The glow discharge causes particles of molybdenum to be sputtered from the cathode surface, said particles reacting with the gaseous filling to remove any impurities such as oxides therefrom, said oxides being locked up or occluded by the particles. These particles collect on the other elements of the tube and the envelope, as well as on the cathode itself.

The sputtering operation is continued for a sufficient length of time to exposed a clean surface on the cathode and to completely clean the gaseous filling. It has been found that to accomplish the complete cleaning operation, a period on the order of one to two hundred hours of constant sputtering is necessary. When the gas and the cathode surface are completely cleaned, it has been found that the tube does not become recontaminated by action of the gaseous filling on the envelope 10, as was previously believed. Therefore, it is immaterial whether the inside of envelope 10 becomes covered with the sputtered material, and indeed, it is desirable that the sputtered material return in large part to the cathode surface. The use of a cathode surrounding the anode is conducive to the return of the sputtered material to the cathode surface.

Further, since the cathode surrounds the anode, a large area is exposed to the anode surface thereby producing a device which is capable of carrying relatively high currents for a tube of this size.

This completes the description of the particular embodiment of the invention illustrated herein. However, many modifications thereof will be apparent to persons skilled in the art. For example, any desired gaseous medium may be used for filling the envelope 10. The envelope 10 need not necessarily be made of glass, but could be metal or other materials. The electrode assembly could be modified, if desired, to include any number of grids or auxiliary electrodes. Therefore, it is desired that this invention be not limited to the particular details of the embodiment described herein, except as defined by the appended claims.

What is claimed is:

1. The method of processing a molybdenum cathode gaseous-discharge device comprising filling the envelope of said discharge device with a gaseous medium, sealing off said envelope before producing any discharge of said device, and maintaining a discharge between said cathode and another electrode of said device for a period sufficient to clean said cathode surface.

2. The method of processing a molybdenum cathode gaseous-discharge device comprising filling the envelope of said discharge device with a gaseous medium, sealing off said envelope before producing any discharge of said device, and maintaining a glow discharge between said cathode and another electrode of said device for a period sufficient to clean said cathode surface.

3. The method of processing a gaseous-discharge device having an anode and a molybdenum cathode comprising filling the envelope of said discharge device with a gaseous medium, sealing off said envelope before producing any discharge of said device, and maintaining a discharge between said cathode and said anode for a period sufficient to clean said cathode surface.

4. The method of processing a gaseous-discharge device having an anode and a molybdenum cathode comprising filling the envelope of said discharge device with a gaseous medium, sealing off said envelope, and maintaining a discharge between said cathode and said anode for a period sufficient to clean said cathode surface, the magnitude of said discharge being sufficient to produce substantial sputtering of said cathode surface.

5. The method of processing a gaseous-discharge device having an anode and a molybdenum cathode comprising filling the envelope of said discharge device with a gaseous medium comprising neon, sealing off said envelope, and maintaining a glow discharge between said cathode and said anode for a period sufficient to clean said cathode surface, the magnitude of said discharge being sufficient to produce substantial sputtering of said cathode surface.

6. The method of processing a molybdenum cathode gaseous-discharge device comprising filling the envelope of said discharge device with a gaseous medium, sealing off said envelope, and maintaining a discharge of sufficient magnitude to cause sputtering of said cathode between said cathode and said anode for a total period in excess of one hundred hours.

7. The method of processing a molybdenum cathode gaseous-discharge device comprising filling the envelope of said discharge device with a gaseous medium, sealing off said envelope, and maintaining a discharge between said cathode and another electrode of said device for a period sufficient to clean said cathode surface, the magnitude of said discharge being sufficient to produce substantial sputtering at said cathode surface.

8. The method of processing a gaseous-discharge device having a cathode and another electrode comprising filling the envelope of said discharge device with a gaseous medium, and maintaining a discharge between the cathode and said electrode of said device for a period sufficient to clean the surface of said cathode, the magnitude of said discharge being sufficient to produce substantial sputtering at said surface.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,720,172	Dessauer	July 9, 1929
1,927,812	Thomson	Sept. 19, 1933
2,290,208	Quarrie	July 21, 1942
2,440,154	Oles	Apr. 20, 1948