

March 12, 1957

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2,785,093

METHOD OF PREPARING CATHODES FOR DISCHARGE DEVICES

Filed June 29, 1954

2 Sheets-Sheet 1

FIG. 1

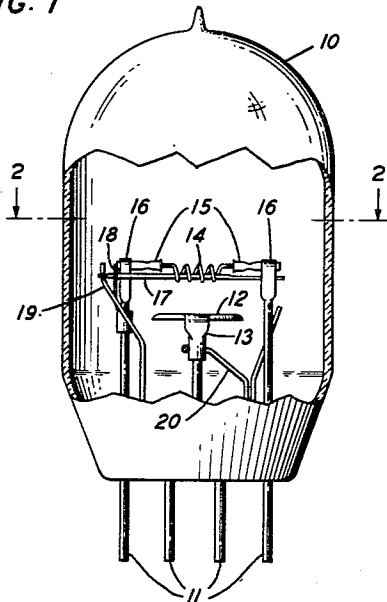


FIG. 2

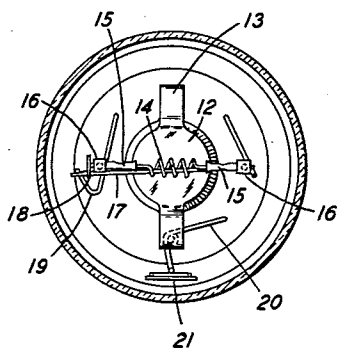
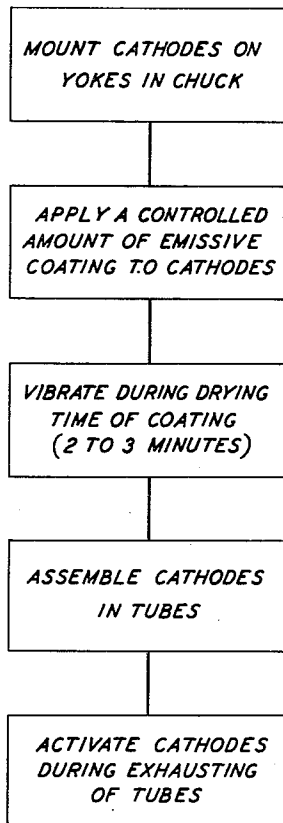


FIG. 3



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FIG. 4

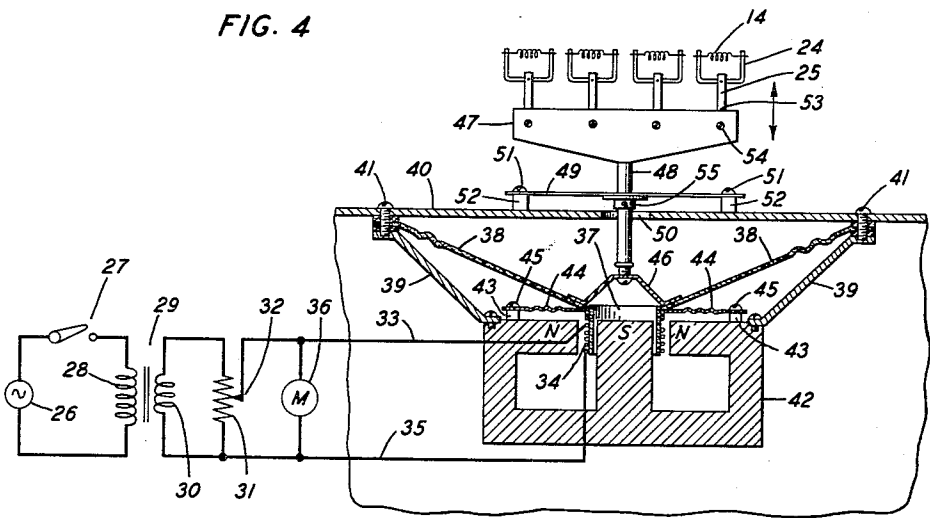


FIG. 5

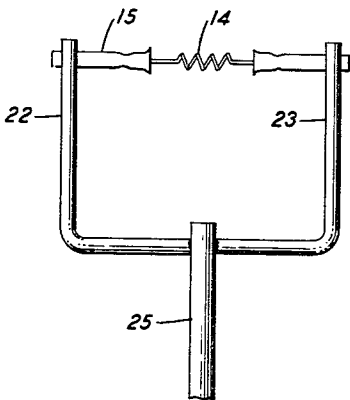
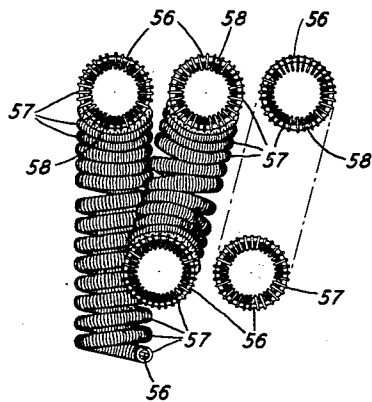


FIG. 6



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Application June 29, 1954, Serial No. 439,964

8 Claims. (Cl. 117—201)

This invention relates to electrodes for space discharge devices and more particularly to the fabrication and preparation of coated cathodes for such discharge devices.

An important aspect of the invention resides in improvements in the preparation of cathodes of the so-called "overwound filament" type, such as the coil electrode shown in Patent 2,306,925 to John O. Aicher, granted December 29, 1942. In an electrode of this character, a fine wire is helically wound on a comparatively large conductor, the overwinding being sufficiently loose to provide interstitial spaces for holding and retaining a coating of electron emissive material. This composite structure of coil and conductor is then coiled up into a larger coil which is recoiled to form a triple coil cathode having two wires and three helices. A device of this type comprises a very satisfactory cathode for ionic-heated operation as it is characterized by easy starting and long life.

In accordance with conventional practices, cathodes of the type described above are usually supplied with a coating comprising one or more alkaline earth metal oxides, such as barium, strontium, and calcium oxide, or combinations of the same.

Normally, the coating is applied to the cathode in a finely divided form, as, for example, the carbonates of the alkaline earth compounds. For ease of coating, the compounds are dispersed in a volatile vehicle in which they are not soluble and to which has been added a binder material. Advantageously, the volatile vehicle may be amyl acetate and the binder material nitrocellulose. During or shortly after the coating process the vehicle evaporates, leaving the alkaline earth compounds in place on the cathode. Subsequent heating of the cathode and the coating under suitable low pressure conditions drives off the binder and breaks down the carbonates to the oxides. Variations in the conditions during heating may advantageously be employed to activate the oxides and render them highly emissive.

Prior modes of application of the emissive cathode coating material to the turns formed by the fine wire overwinding have not proved entirely satisfactory. The usual methods of coating such as dipping and spraying generally result in both the smaller helix formed by the fine wire and the larger helices formed by the composite structure of the second and third windings becoming filled with the coating. In addition, the coating is frequently of uneven and non-uniform density on the coils and contains undesirable void areas. The coating has also been priorly applied by means of an eyedropper to permit the coating to flow more freely into the turns of the coil. However, as in the case of spraying and dipping, the larger helices become filled with coating and it has been necessary to remove the excess material by blowing air under pressure from an air jet through the larger turns of the helices.

The principal objects of the present invention are to overcome the aforementioned difficulties and to provide a reliable and efficient method of coating an electrode in

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a uniform manner in which a subsequent removal of excess coating material is not required.

These and other objects are realized in a specific illustrative embodiment of this invention in which a cathode coil has a small amount of emissive material deposited thereon and is subjected to vibration during drying to cause the coating to flow evenly as into the interstitial spaces of a small wire helix.

The coating method in accordance with one specific embodiment of the instant invention comprises the steps of mounting each of the overwound filament cathodes on a supporting yoke and placing each yoke in a chuck attached to a vibratory source, which advantageously may be the voice coil of a dynamic loudspeaker. A drop of the emissive cathode coating is then placed on the cathode coil, as with an eyedropper. While the vehicle of the coating is drying and evaporating, the coil is made to vibrate at an audio frequency which not only permits the coating to flow uniformly into the turns of the overwinding but also compacts the coating so that it is more densely located within the cathode and does not bridge the turns or fill the windings of the coil. The prepared cathodes are then assembled in their respective discharge devices where the binder is burned off and the coating reduced to oxides by heating during the exhausting of the discharge devices.

In accordance with one feature of this invention, the cathode of a space discharge device is coated by applying a small amount of the coating material to the cathode coil and vibrating the coil during the drying of the cathode coating.

More specifically, it is a feature of this invention to coat a cathode of the overwound filament type by applying a controlled amount of coating material to the cathode coil by means of an eyedropper and to subject the coil to vibration at a low audio frequency during drying to distribute the coating material more uniformly in the interstitial spaces of the coil.

It is a further feature of this invention that the vibratory motion for the cathode coil during the drying process be supplied from the voice coil of a dynamic loudspeaker which is energized by an audio frequency voltage.

A complete understanding of this invention together with the above-noted and other features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a side elevational view in partial section of a discharge device incorporating a cathode prepared in accordance with the invention;

Fig. 2 is a plan view of the discharge device of Fig. 1 along the line 2—2 thereof;

Fig. 3 is a chart showing the steps constituting one method of preparing a cathode in accordance with the present invention;

Fig. 4 is a schematic diagram of a circuit employed in the coating process of the present invention;

Fig. 5 is an enlarged elevational view of a coiled cathode mounted on a supporting yoke; and

Fig. 6 is a sectional view of a portion of a coiled cathode on a larger scale, showing the construction thereof.

Referring now to the drawing, Fig. 1 shows a specific illustrative embodiment of a glow discharge device in which a cathode coil prepared in accordance with the present invention may be employed. The discharge device is a gas diode comprising an envelope 10, a plurality of stem lead wires 11 extending through the base of the envelope 10, an anode comprising a circular disk of nickel 12 supported by a formed tab 13 attached to one of the stem lead wires 11, and a cathode 14, which preferably consists of a coiled coil of tungsten wire in which the first

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coiling has a loose overwinding of finer tungsten wire. Each end of the major coil of a cathode 14 is slipped into a short section of nickel sleeving 15 which is loosely crimped as shown in Fig. 1 and in the enlarged view of Fig. 5. Two of the stem lead wires 11 have their uppermost ends bent into hooks 16 into which the sleeves 15 supporting the cathode coil 14 are slipped. The hooks 16 are pressed closed and spot welded to securely maintain the cathode structure in the desired position.

A support rod 17, which advantageously may be constructed of molybdenum wire coated over substantially its entire length except near the ends with a highly refractive insulating material, such as aluminum oxide, is positioned through the center of the major coil of the cathode 14. This rod serves as a mechanical support for the coil 14 in the event of breakage of the coil and prevents an accidental anode-to-cathode short circuit. One end of the support rod 17 is inserted into the hooked stem lead wire 16 and clamped thereto at the same time as the cathode sleeve 16 so as to be in electrical contact with the coil 14. The other end of the cathode support rod 17 is passed through a supporting eyelet 18 and attached to a separate support wire 19 which is returned to one of the stem lead wires 11. The aluminum oxide layer on the cathode support rod 17 serves to electrically insulate the support rod from the cathode coil except at the one common stem lead wire 16. This arrangement permits both the cathode coil 14 and the support rod 17 to be individually heated during processing of the discharge device.

Fig. 2 is a plan view of the space discharge device of Fig. 1 which shows more clearly the positioning of the support rod 17 with respect to the cathode coil 14. Attached to one end of the anode 12 by the support wire 20 is a getter 21, not shown in Fig. 1. The getter advantageously may be an iron core filled with pure barium in which one edge of the iron core is ground down so that only a thin surface remains over the barium. The getter 21 preferably is arranged to be flashed onto the inner wall of the envelope 10 by high frequency induction heating.

Fig. 3 is a chart of the steps to be followed in preparing a cathode in accordance with one embodiment of the present invention. Each cathode coil 14, together with its associated sleeves 15 is attached to the opposite arms 22 and 23 of a wire yoke 24 having a support bar 25, all of which advantageously may be made of nickel wire. This arrangement is shown in Fig. 5 of the drawing. The yokes of the cathodes to be coated are then mounted in a chuck which is driven at a low audio frequency rate by a vibrator mechanism such as the voice coil of a dynamic loudspeaker to which an alternating current voltage has been applied.

A partial section of the structure of one illustrative embodiment of coiled cathode 14 which may advantageously be used with this invention is shown in detail in Fig. 6. The larger electrode wire 56 has an overwinding of finer wire 57 which is sufficiently loose so as to provide a plurality of interstitial spaces 58 for holding the emissive cathode coating. These are coiled up to form the coiled coils 59. The coiled coils 59 are coiled once again into larger coils, shown in section in Fig. 6, thus making a coiled coil of the larger wire 56 and a triple coil of the finer wire 57.

An eyedropper or similar type of device may be used to place a controlled amount, such as a drop, of emissive coating on the center of each of the cathode coils in the chuck before the vibration period. This coating may be any of the electron emissive compositions available in the art but advantageously comprises a mixture of 45 percent barium carbonate and 55 percent strontium carbonate in a suitable binder such as nitrocellulose, and thinned to a workable viscosity by the addition of a suitable vehicle such as amyl acetate. With the coating applied, the vibration is started and continued for approximately two to three minutes while the vehicle of the coating is drying and evaporating. This serves to cause the coating to flow evenly into the interstitial spaces of the fine wire helix

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of each cathode coil thereby to distribute the coating material in a uniform manner. In addition, the vibration compacts the coating so that it is more densely located within the cathode. The amount of coating is controlled such that the second coiling is not filled and that the space between turns of the second coiling are not bridged.

After the completion of the coating process, each cathode assembly and the nickel sleeves 15 thereof is inserted into the stem lead wire hooks 16 of a discharge device as described above, clamped and welded. The yoke 24 is then cut free and discarded. The remaining components of the tube structure are then assembled on their respective support wires and the bulb portion of the envelope 10 sealed to the stem.

The discharge device after being assembled may be exhausted in a conventional manner. Through the appropriate lead wires 11 an electric current is passed through the cathode coil to activate the cathode by heating and converting the barium and strontium carbonates into oxides. The separate stem lead connection for the support rod 17 through the rod end 18 and the support wire 19 permits the support rod 17 to also be heated by an electric current at this time so that both the cathode coil and support rod are heated during processing.

The processing of the discharge device is completed by outgassing the anode 12, which advantageously is accomplished by high frequency induction heating, flashing the getter 21, and filling the envelope 10 with argon or similar gas to a suitable pressure, as is known in the art.

Fig. 4 shows an illustrative embodiment of one specific type of vibrator which may be used in accordance with the present invention. A source of alternating current excitation voltage 26 is connected in series with the primary winding 28 of a transformer 29 and with the contacts of a normally open switch 27. The secondary winding 30 of the transformer 29 is connected across the resistance portion of a potentiometer 31, the sliding contact 32 of which is connected through the lead 33 to one end of the voice coil 34 of a dynamic loudspeaker which has been adapted, as explained below, to vibrate the cathodes to be coated. The other end of the voice coil 34 is connected via the lead 35 to the potentiometer 31 and the transformer winding 30. A voltmeter 36 may be connected across the voice coil 34 so the potentiometer contact 32 may be adjusted to any desired voice coil excitation voltage.

As indicated above, the vibrator may be comprised of a dynamic loudspeaker having its voice coil connected to a source of audio frequency voltage. The voice coil 34 is wound around the apex portion 37 of the speaker cone 38, the outer edge of the flexible rim of which is secured to the support brackets 39 and the vibrator housing 40 by the bolts 41. The brackets 39 are fastened to the permanent magnet 42 which has its pole pieces in proximity with the voice coil 34 to provide a strong magnetic field therefor. The voice coil 34 is held in position by a centering disk or spider 44 which is attached to the cone apex 37 to permit movement of the cone in the vertical direction upon excitation of the voice coil. The spider 44 is positioned above the permanent magnet 42 by the spacers 43 which are secured to the magnet by the bolts 45. A bracket 46 in the form of a truncated cone is adhesively attached to the speaker cone 38 by glue or similar means. A chuck 47 having a shaft 48 is bolted to the bracket 46 through an opening 50 in the vibrator housing 40. A flexible spider 49, which is secured to the housing 40 by the bolts 51 and the spacers 52, serves to permit the chuck to vibrate in the vertical direction only. A flanged ring 55 is secured to the shaft 48 and positioned beneath the spider 49 to provide a supporting contact for the spider 49. The upper surface of the chuck has a plurality of apertures 53 for receiving the cathode yoke support bars 25 which are secured therein by means of the set screws 54.

The frequency chosen for the source of field coil ex-

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citation voltage 26 may advantageously be a low audio frequency such as 60 cycles per second. The amplitude of the vibrations is controlled by means of the potentiometer sliding contact 32 which may be adjusted in accordance with the reading on the voltmeter 36. When the excitation voltage is applied to the field coil 34 the action of the magnetic field of the permanent magnet 42 on the coil current causes the entire cone assembly including the chuck 47 to vibrate in the vertical direction with the support of the flexible spiders 44 and 49. The emissive coating is advantageously applied to the cathodes 14 mounted in the chuck with switch 27 open and the cathodes at rest. Switch 27 is then closed causing vibration to take place and the vibration is continued during the drying time of the coating which is in the order of two or three minutes after the coating is applied. Switch 27 is then opened, stopping the vibration, and the cathodes are removed from the chuck. They are then assembled in the space discharge devices in accordance with the present invention as explained in detail above. It is to be understood that the arrangements shown and described in the instant drawing and specification are but illustrative of the application of the principles of this invention. Numerous other arrangements may be made by those skilled in the art without departing from the spirit and the scope of the invention.

What is claimed is:

1. The method of preparing a cathode having a plurality of interstitial spaces comprising the steps of placing a controlled amount of an electron emissive material and binder dispersed in a vehicle on said cathode and vibrating said cathode at an audio rate while the vehicle is drying and evaporating to cause said electron emissive material to flow into said interstitial spaces in a uniform manner.

2. The method of coating a filamentary cathode of the type having an overwound helix providing a plurality of interstitial spaces comprising the steps of mounting the cathode in a vibrator, applying a drop of electron emissive material to said overwound helix, vibrating said cathode at an audio rate to cause said emissive material to flow evenly into said interstitial spaces, and causing the vibrations to cease when said emissive material is uniformly distributed within said interstitial spaces.

3. The method of coating a cathode of the overwound filament type comprising placing a drop of a composition comprising an electron emissive material on a cathode coil having an overwinding sufficiently loose to provide

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interstitial spaces for holding and retaining said electron emissive material and subjecting the cathode to vibration at an audio rate for a period of time sufficient to cause said emissive material to flow evenly into said interstitial spaces and provide a uniform coating for said cathode.

4. A method for coating an electrode which comprises placing an emissive material and binder dispersed in a suitable vehicle upon an electrode and causing said electrode to vibrate at an audio rate during the drying time of said vehicle to cause said emissive material to be uniformly coated upon said electrode.

5. The method of coating a cathode of the overwound filament type comprising the steps of mounting the cathode in a vibrator, placing a drop of electron emissive coating material on said cathode, and vibrating said cathode at an audio rate until the electron emissive material is evenly distributed around the windings of the cathode.

6. The method of preparing a filamentary cathode with a uniform emissive coating comprising the steps of placing a drop of electron emissive material and binder dispersed in a suitable vehicle on the cathode and subjecting the cathode to vibration at an audio rate during the drying time of the vehicle to cause the coating to flow evenly over substantially the entire surface of the cathode.

7. The method of coating cathodes of the overwound filament type for space discharge devices comprising the steps of applying a small amount of electron emissive coating material to the windings of the cathode and vibrating the cathode at an audio rate during the drying time of the coating to cause the coating to be evenly distributed in the turns of the windings.

8. The method of preparing a cathode of the type having a first coil of a wire having an overwinding of a finer wire thereon, said first coil and overwinding being wound into a second coil, comprising the steps of applying an electron emissive material to said cathode and vibrating said cathode at an audio rate during the drying time of said emissive material, in which the amount of emissive material is controlled such that there will be no filling of the coils or bridging of the turns of said second coil.

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