

Oct. 7, 1952

W. P. TOORKS

2,613,164

METHOD OF COATING ELECTRON EMISSIVE CATHODES

Original Filed May 23, 1945

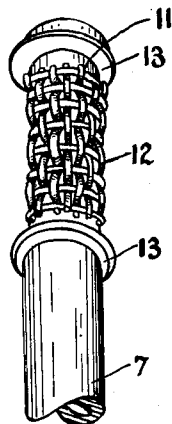


Fig. 1

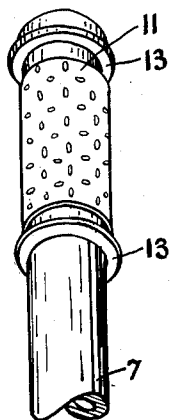


Fig. 2

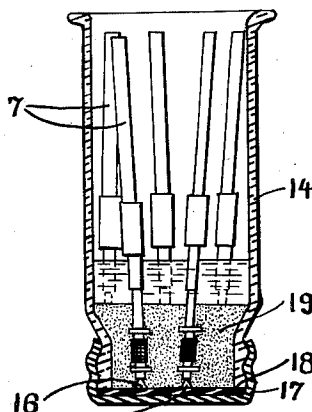


Fig. 3

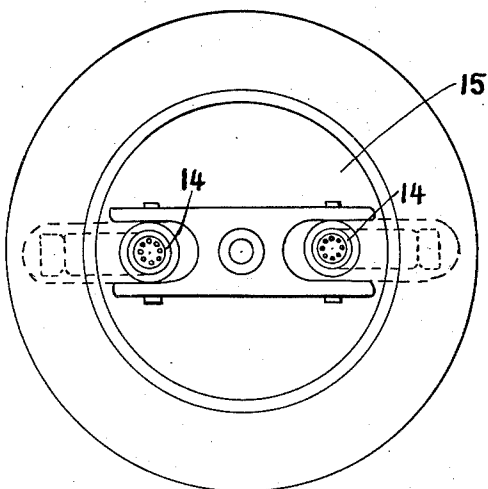


Fig. 4

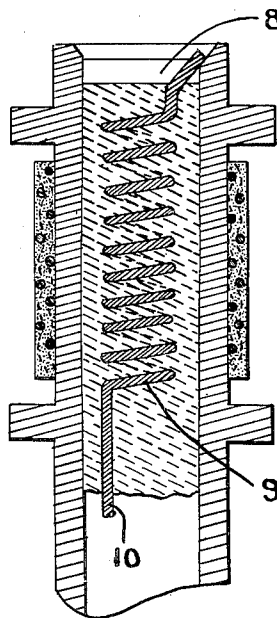


Fig. 5



Fig. 7

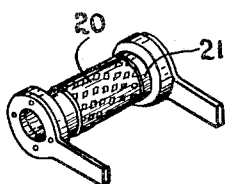


Fig. 6

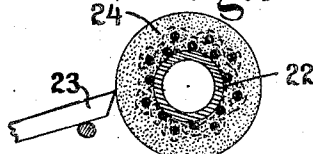


Fig. 8

INVENTOR.
William P. Toorks
BY *Lawrence Burns*,
ATTORNEY

UNITED STATES PATENT OFFICE

2,613,164

METHOD OF COATING ELECTRON EMISSIVE CATHODES

William P. Toorks, Roxbury, Mass., assignor to
Sylvania Electric Products Inc., Salem, Mass.,
a corporation of Massachusetts

Original application May 23, 1945, Serial No.
595,309. Divided and this application Decem-
ber 30, 1947, Serial No. 794,519

4 Claims. (Cl. 117—33.19)

1

This invention relates to electronic cathodes bearing a coating of electron emissive material and to a method of applying the coating. This application is a division of application Serial No. 595,309, filed May 23, 1945, issued December 30, 1947, as Patent #2,433,821.

In the use of electronic devices the proper function of the cathodes therein is of vital importance since they are the source of electrons upon which the operation of the device depends. The useful life of the device and its efficient operation depend directly upon the proper function of the cathode.

The number of electrons obtainable from the cathode is greatly increased by applying a coating of electron emissive material thereon. By applying a relatively thick coating to the cathode its life is prolonged. It is highly important however, that the coating be formulated and applied with particular care to insure the full benefit therefrom.

It is the general object of the invention to increase the life and efficiency of the cathode and particularly its coating.

A specific object of the invention is to provide an electron emissive cathode coating which is homogeneous and of maximum density.

A further object of the invention is to provide a cathode coating which is evenly and completely distributed over the emissive areas of the cathode.

A further object of the invention is to provide a method of applying the emissive coating to cathodes which will insure maximum performance and complete uniformity thereof.

Electronic emissive coatings heretofore applied have lacked the required resistance to disintegration and high emissive quality to insure highest possible performance. The coating provided by the present invention exhibits several important improved features. It is characterized by a uniformly increased density. Its adherence to the cathode proper is very secure being chemically and mechanically perfect.

When the invention is applied to a cathode having a mesh screen or the like upon its emissive area the beneficial results are particularly effective. In such case the active material adheres strongly to and covers every portion of the mesh. The full effectiveness of the added material held by the mesh is thus obtainable without the possibility of premature disintegration and loss of material.

The emissive material is applied to the cathode in a specific manner. Any suitable emissive material may be used. The material is mixed in suspension in a volatile liquid and the liquid is placed in the containers of a centrifuge. The cathodes are immersed in the liquid and centrifuged for a given period desirably in several steps between

2

which steps the liquid solvent is removed. After centrifuging the cathodes are removed from the dense mass of emissive material and their exteriors smoothed to present an even surface and after drying, all material is removed from areas not intended for electron emission thus leaving a dense homogeneous layer of coating material upon the cathode.

To present a better understanding of the invention a particular embodiment thereof will now be described in connection with the accompanying drawings, in which:

Figure 1 is a perspective view of a cathode before its emissive material is applied;

Figure 2 is a view of a completed cathode;

Figure 3 is a cross sectional view of a centrifuge container showing the coating material and the cathode therein;

Figure 4 is a top plan view of a centrifuge suitable for processing the cathodes;

Figure 5 is an enlarged cross sectional view through a completed cathode;

Figures 6 and 7 illustrate other types of cathodes to which the invention may be applied; and

Figure 8 illustrates a cathode forming operation.

The invention may be applied to any cathode and is particularly adapted to cathodes having metallic mesh thereon to receive the emissive material. One such cathode is illustrated in the drawings and is provided with a body 7 of suitable metal such as nickel. The body 7 desirably is tubular in form presenting an aperture 8 within which a heating element 9 is received and through which the heater lead wires 10 are fed.

The electron emissive section 11 of the cathode shown in Figures 1, 2, 3, and 5 is confined to one end thereof, the remaining portion serving as a support and a conductor for carrying current. The section 11 desirably is provided with a section of metallic mesh 12 extending around the outside of the cathode and in contact therewith. The mesh may be sintered into contact with the cathode. The cathode may also be provided with flanges 13 adjacent the ends of the gauze 12. The flanges 13 do not constitute a part of the invention but serve to influence the general operation of the tube in which the cathode is used.

Any suitable cathode coating material may be used. A satisfactory material consists of approximately a 2% solution of nitrocellulose in amyl acetate to which is added a suitable electron emissive material such as a combination of barium, strontium and calcium carbonates. The active material is mixed with the nitrocellulose solution to form a suspension thereof. Barium, strontium and calcium carbonates are the materials which, in their final state, constitute the

3

electron emissive coating and are termed "electron emissive material" even though they may not be electron emissive at this stage of their processing.

The viscosity of the suspension is relatively low and may be of a conventional value. A number of cathodes are then placed emission end down in each tube 14 of the centrifuge 15. An equal number is placed in each tube to provide the proper balance for operation of the centrifuge. The apertures 8 are plugged to prevent coating material from entering. The plugging may be done by means of small clean wooden plugs 16.

A quantity of coating is then placed in each tube 14. Sufficient material is used to cover the cathodes to a point a substantial distance above the gauze 12. The centrifuge is then operated for a period of substantially forty-five minutes at full speed. The liquid above the partially packed mass in the tube is then syphoned off and more coating material is added to bring the level up to the original level. The centrifuge is again run at full speed for approximately thirty minutes and the liquid syphoned off. The centrifuge is then operated for between three and four hours removing the liquid at intervals when necessary. The times for centrifuging are given by way of example. The desired result may be achieved by a suitable period of treatment depending upon the conditions such as the viscosity of the material and the speed of the centrifuge.

Approximate values for test runs made with emissive material of approximately 2 micron particle size following the procedure above-outlined are as follows. In a test in which the centrifuge was operated at 715 gravities for 5 hours a density of 1.64 was attained. In other tests when operating the centrifuge at 2250 gravities for 5 hours and 22 hours respectively, densities of 2.4 and 2.64 were attained. These are bulk densities, in grams per cc.

The coating material will now be found to have formed a firm condensed cake in which the ends of the cathodes are embedded. By reason of the action of the centrifuge the coating material will be perfectly distributed with a firm even density upon every portion of the exposed portions of the cathodes and the gauze bands 12. The pressure exerted upon the particles of material in suspension during centrifuging insures the best possible arrangement of the material and also perfect adhesion of the material to the cathode surfaces. By centrifuging in the manner described a very large proportion of the liquids in the suspension are removed and the active material is thus densified substantially to its final volume before drying. Thus the final condition of the coating is determined by the centrifuging operation. In contrast to this highly efficient result prior to the present invention the suspension of coating material was painted on the cathode by hand. Such procedure failed to produce the desired result. Lack of uniformity caused many rejected cathodes and a general spotty porous condition in the coating prevailed due to lack of proper packing of the material. This lack of quality resulted also from the fact that when coated by hand the material contained a relatively large percentage of liquid solvent and temporary binder which when finally removed left the coating in a weakened condition containing an amount of active particles much less than is the case when the present invention is practiced. Also a coating applied by hand or

4

by spraying, contains voids and air holes which lower its efficiency. This condition is overcome in the present invention by the centrifuging operation which insures that not only will there be no voids or air holes in the coating but that the material will firmly pack into all the spaces in and formed by the mesh.

Desirably the tubes 14 are provided with screw caps 17 and a nickel gasket 18 to close their bottom ends. This construction provides for ready removal of the cathodes after centrifuging. The caps 17 are removed and by means of a plunger which substantially fits the tube, the cake 19 containing the cathodes is pushed out through the top of the tube and desirably is placed in a shallow container to hold the cake in shape and each cathode is removed from the cake by withdrawing while rotating it with the fingers. Before the coating has dried completely it is smoothed down upon the mesh. This may be done in any suitable manner such as by mounting the cathode in a revolving spindle and holding a wooden or glass spatula against the surface of the coating and thus scraping the cathode. The coating should be leveled off upon its surface so that only the outermost or high spots of the gauze are visible. In smoothing or leveling the coating material as above described its thickness may be varied to a desired extent by removing more or less of the material adhering to the emissive portion of the cathode.

The cathodes are then set aside and allowed to completely or partially dry. In connection with the cathode above described all coating material is then carefully removed except that upon the electron emitting section. The plugs 16 are removed and any material which has seeped past the plugs is cleaned from the walls of the aperture 8. The cathodes are then ready to be assembled in the particular electronic device for which they are designed.

Other types of cathodes may be coated such as those illustrated in Figures 6 and 7. The cathode shown in Figure 6 lends itself to the coating method of the invention. This type of cathode may or may not be provided with a screen of gauze 20 wound upon the central portion of its cylindrical body 21. These cathodes are treated similarly to the cathodes 7 except that they are completely covered by the cake of coating material at the end of the centrifuging period after which the cathodes are removed from the cake preferably endwise. The coating material is then smoothed down upon the gauze 20 in the manner above described and after drying, the cathode is cleaned up by removing all material adhering to its non-emissive portions.

Other types of cathodes may also be treated in a similar manner such as the filamentary cathode shown in Figure 7. This cathode is used in electric discharge lamps such as the hot cathode fluorescent lamp.

It has been found in use that cathodes prepared in accordance with the invention have exhibited extremely efficient characteristics and long life. This is especially true when the cathodes are used in the severe service wherein the cathode is called upon to deliver pulses of high instantaneous current density. In such service it has been found that an increase in efficiency of as high as 200 to 900% over that exhibited by cathodes prepared in the conventional manner was obtained.

The practice of the present invention provides a means for producing a coating of a desired den-

sity with a high degree of accuracy. With suspensions containing electron-emitting material of a given particle size, the density of the coating may be controlled to an accuracy of plus or minus 3% over a wide range of density values. This control is established by the speed of the centrifuge and the duration of the centrifuging period. The speed of the centrifuge more properly should be expressed in gravities which would then apply to a centrifuge of any type and dimensions. This control is maintained independently of all other factors for example, atmospheric conditions, operating temperature, operator technique, impurities in the material and other factors.

The method of the invention can be applied to all types of cathodes including not only those having a smooth surface but also those having irregular or reticulated surfaces of such form that at least some of the reticulations are superposed upon or masked by other reticulations. Such cathodes cannot be completely filled by the conventional methods of spraying, painting and cataphoresis. The present invention however, completely fills such cathodes eliminating holes caused by air or gas pockets and permeates all of the interstices formed by the reticulated surface with coating material having a homogeneous density throughout.

The coating as applied by the present invention may be molded into a desired form before it dries or it may be machined to close tolerances after it dries. As shown in Figure 8 a coated and dried cathode 22 is shown in cross-section arranged to be rotated by any desired power means. A tool 23 is mounted or supported in any desired manner and held in cutting relation to the coating material 24 to thus form the coating accurately to a predetermined dimension.

It has been found that coatings prepared according to the invention because of their uniform density require greatly reduced amounts of binder as compared to the conventional coating. It has even been found practical in some instances to use no binder.

Another advantage of the invention is that contamination during the process is reduced to a minimum because the procedure may be carried out in enclosed apparatus thus reducing contamination from the atmosphere.

A cathode coating of finely-divided powders is, of course, porous because of the spaces between the closely-packed particles. The present invention reduces this porosity by packing the particles still closer together and thereby increasing the bulk density to the figures given earlier in this application. In painting cathodes by hand, as is generally necessary with mesh cathodes, the bulk density of the coating is extremely non-uniform, and even with sprayed cathodes the coating density is different near the metal base surface than at a distance from the base. My invention produces a uniform density throughout the distance from the base. My invention produces a uniform density throughout the volume of the coating.

In using a centrifuge according to my invention it is desirable to keep the vibration as small as possible, because vibration tends to diffuse the coating particles and hence to counteract the centrifuging action.

What I claim is:

1. The method of coating an external portion of a hollow or cylindrical cathode with an electron emissive powder the portion to be coated

having numerous interstices, comprising the steps of immersing the cathode in a coating suspension of electron emissive powder in a volatile liquid containing a small percentage of temporary binder, centrifuging the cathode in the suspension so as to compact the powder about and within the interstices of the cathode and thus depositing on the exterior thereof an adherent coating in excess amount, and thereafter cutting the excess coating material from the cathode.

2. The method of coating an external surface of an open-ended hollow cylindrical cathode, including the steps of plugging the open end of the cathode, immersing the cathode in a liquid suspension of a powder of electron emissive material in a volatile liquid containing about 2% of temporary binder relative to the volatile liquid, the extent of immersion being a substantial distance above the surface to be coated, centrifuging the cathode for a long period of time whereby a dense coating of electron-emissive material is compacted about the cathode in excess of the amount finally desired to remain on the cathode, and after centrifuging removing the excess of the dense compacted coating from the cathode by scraping.

3. The method of providing a portion of the exterior of a cathode with an electron emissive surface, which includes the steps of immersing the cathode in a liquid to an extent substantially beyond that required to cover said exterior portion, said liquid containing a powder of electron emissive material suspended in a volatile liquid containing a small percentage of a suitable temporary binder, centrifuging the cathode for a long period of time whereby a soft but dense coating of electron emissive material is compacted about the cathode in excess of the amount finally desired to remain on the electron emissive portion of the cathode, and after centrifuging, mechanically removing the excess of the dense compacted coating from the cathode while the coating is still soft.

4. The method of providing a dense electron emissive coating on an external mesh-covered region of a cathode which includes the steps of blocking off a region of the cathode that is not to be coated, immersing the cathode in a liquid substantially beyond the extent required to cover the region to be coated, said liquid having in suspension an electron emissive powder, centrifuging the cathode for a long period of time whereby a dense coating of the electron emissive powder is compacted about the cathode in excess of the amount finally desired to remain on the cathode, and after centrifuging, mechanically removing the excess of the dense compacted coating from the cathode.

WILLIAM P. TOORKS.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
934,833	Parker	Sept. 21, 1909
1,217,071	Rust	Feb. 20, 1917
1,532,533	Harris	Apr. 7, 1925
1,939,075	McCulloch	Dec. 12, 1933
2,009,232	Hood	July 23, 1935
2,119,309	Batchelor	May 31, 1938
2,158,981	Collins et al.	May 16, 1939
2,355,232	Nelson et al.	Aug. 8, 1944