July 31, 1934. E. F. LOWRY 1,968,608

HIGH EFFICIENCY OXIDE COATED CATHODE AND METHOD OF MANUFACTURE

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Fig. 1.

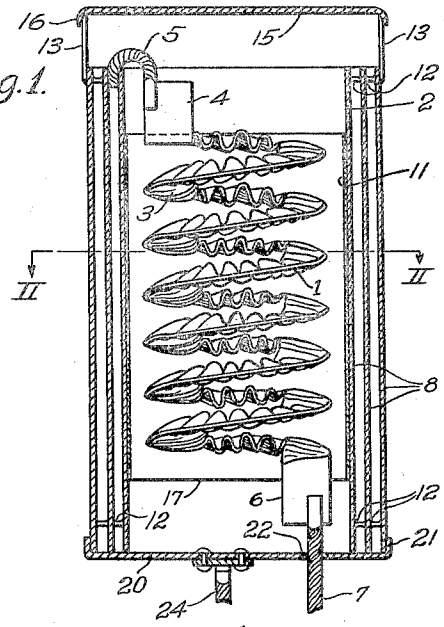


Fig. 2.

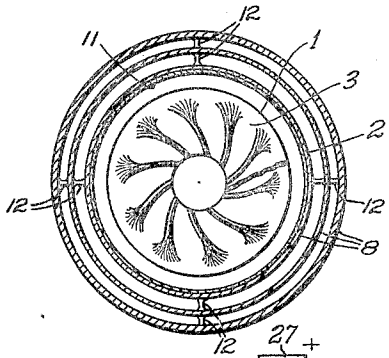


Fig. 3.

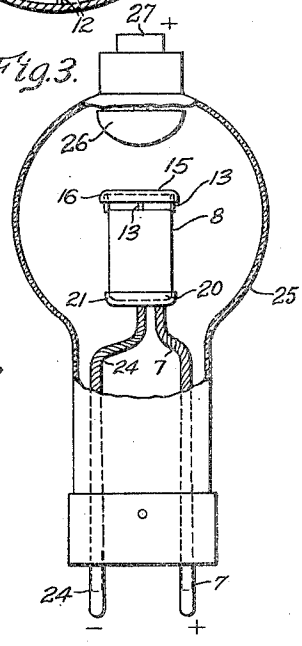


Fig. 4.

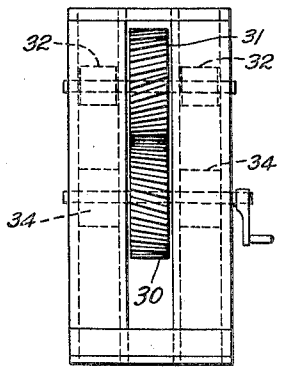


Fig. 5.

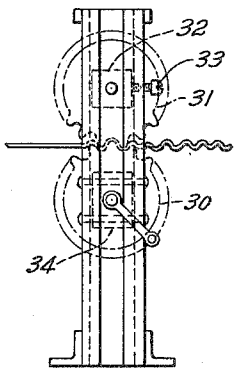
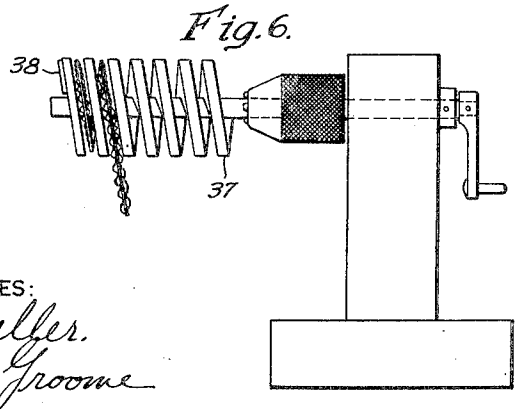


Fig. 6.



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HIGH EFFICIENCY OXIDE COATED CATHODE AND METHOD OF MANUFACTURE

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Application May 20, 1932, Serial No. 612,505

12 Claims. (Cl. 250—27.5)

This invention relates to cathodes and particularly to cathodes for use in connection with gas filled tubes such as frequently used for rectifiers.

It is an object of this invention to obtain the desired quantity of electron emission with a smaller expenditure of heating energy than has heretofore been required.

It is a further object of my invention to provide a cathode comprising a heating member and a radiation shield both of which shall participate in the electron emission.

It is a further object of my invention to produce a ribbon of cathode material capable of being wound edgewise.

It is a further object of my invention to provide a cathode structure of large electron-emission surface and relatively small effective radiation surface.

It is a further object of my invention to cause the heater of an indirectly heated cathode to function also as a directly heated cathode.

It is a further object of my invention to produce a combination of heater acting as a directly heated cathode and radiation shield acting as an indirectly heated cathode in which the effective radiation surface of the heater shall be of nearly the same area as the electron emissive surface of the shield. Because the effective radiation surface of the heater is nearly equal to the adjacent surface of the shield and both take part in the electron emission I secure a more nearly uniform temperature throughout the whole cathode.

It is a further object of my invention to provide a cathode structure which shall avoid local overheating by the space current.

It is a further object of my invention to provide ample room for passage of electrons from the cathode to the anode while in effect completely surrounding the cathode with a radiation shield.

It is a further object of my invention to manufacture a helix from a strip, the faces of the strip being edgewise toward the axis of the helix, from a material which is not readily stretched.

Other objects of my invention and details of the construction will be apparent from the following description and the accompanying drawing to which reference is made.

In the drawing, Figure 1 is a longitudinal section of the cathode.

Fig. 2 is a view in section taken along the line II—II of Fig. 1.

Fig. 3 is a view partly in section and partly in elevation of a tube in which the cathode structure is used.

Fig. 4 is a view in front elevation and

Fig. 5 is a view in side elevation of apparatus used in the manufacture of the cathode.

Fig. 6 is a view in side elevation of another apparatus used in another step of the manufacture.

Referring to the drawing and in particular to Figs. 1 and 2 thereof, the cathode comprises a strip 1 of nickel, ferro-cobalt-titanium alloy, tungsten or other metal suitable for cathodes, in combination with a shield 2. The strip is in the form of a helix. The width of the strip being nearly normal to the axis of the helix. The strip is corrugated, the corrugations 3 extending transversely of the strip and preferably making a small angle with the radius of the helix. The length of any one corrugation thus extends across the strip but preferably is not normal to the edges thereof. Instead it makes a small angle, such as 15°, with such normal.

These corrugations are deeper at the inner edge of the strip and are flatter at the outer edge. They may even completely disappear at the outer edge so that the extreme outer margin of the strip is uncorrugated.

At the upper end of the helix the strip is bent upwardly, as shown at 4, for connection to a lead 5 and at the lower end it is similarly bent as shown at 6 for connection to a lead 7.

The shield 2 is the inner one of a plurality of concentric cylinders 8, concentric with the helix. The helical portion of the strip 1 and the inner surface of the cylinder 2 adjacent thereto are coated with an electron emissive material, such as the oxides of barium and strontium. The coating upon the inner face of the cylinder 2 extends the length of the helix as indicated at 11, but the cylinder itself extends beyond the helix in both directions and is rigidly connected to the other cylinders 8 by spacing and supporting devices 12 near the top and the bottom of the shield.

At the top of the shield structure a plurality of supports 13 space the end shield 15 from the edges of the cylindrical shields 8, thereby leaving a space between said upper edge and the end shield 15 which is unobstructed except by the supports 13. The edge of the shield 15 is preferably turned downwardly forming a flange 16 and the supports 13 are secured to the outer surface of the outermost cylinder 8 and to the inner surface of the flange 16.

At the bottom of the cylinders 8 they are closed by a bottom shield 20 which is fitted to the outermost cylinder 8 by an up-turned flange 21. An

opening 22 is provided in the bottom shields 20 for the passage of the lead 7.

The lead 5 connects the upper end 4 of the strip to the cylinder 2. This connection may extend to the other cylinders either through the lead 5 or through one or more of the spacing connections 12. The upper end of the strip is thus connected to the bottom member 20 of the shield.

A lead 24 is connected to the bottom member 20 and the leads 7 and 24 extend through the press to the outside of the tube 25 as shown in Fig. 3. The anode 26 is connected through the usual seal to an external terminal 27. The circuit in which the tube 25 is used includes a connection from the terminal 27 to the terminal associated with the lead 24.

The power for heating the cathode is delivered to the leads 7 and 24. The correct phase relation should be maintained in making this connection. At the time that the anode terminal 27 is positive, that is, while the tube is conductive, the heating current should be in such a direction that the lead 7 is positive with respect to lead 24. This has been noted upon Fig. 3 by applying the sign + to terminal 27 and the lead 7 and the sign — to the lead 24. These signs thus stand for the relation between the instantaneous potentials during that half-cycle throughout which the tube is conducting.

In order to manufacture the helical strip 1, a strip of metal suitable for use in a cathode is first passed between a pair of gears shown in Figs. 4 and 5. The gears 30 and 31 are provided with intermeshing teeth which make an angle, preferably about 15°, with the elements of the pitch cylinder of each gear. The upper gear 31 is mounted adjustably as indicated by the blocks 32 and the set screw 33, while the lower gear 30 is mounted in fixed blocks 34.

The depth of the corrugations produced in the strip by means of the gears is regulated by the adjustment of the gear 31. When the strip has been passed through these gears it has a series of uniform corrugations extending obliquely across it at an angle of some 15° with the width of the strip.

In the appaartus shown in Fig. 6 a square-threaded screw 37 is mounted in any suitable support and driven manually or in any convenient manner. The outer end of the screw thread affords a shoulder over which an end of the strip is hooked as indicated at 38. Rotating the screw then causes the strip to be wound upon the screw, the strip entering between adjacent walls of the thread.

During this operation the ends of the corrugations near the outer edge of the strip which are stretched, and thus the corrugations are flattened at their outer ends. The width of the space between adjacent turns of the thread of the screw 37 is sufficient to accommodate the full height of the corrugations. At the inner edges of the strip, therefore, the corrugations are of full depth and are not crushed together or flattened down by any pinching action of the screw.

After it is wound on the screw, the distance along the strip between adjacent corrugations is smaller at the inner edge. The corrugations thus become steeper and deeper at their inner ends and at their outer ends are flattened and may even be completely flat. This is because the winding has brought the corrugations nearer at their inner ends and separated them at their outer ends.

When the winding of the strip upon the screw 37 is completed, the wound strip is removed from the screw by rotating the screw in the opposite direction. The strip thus formed is self-supporting. It possesses considerable rigidity against compression by pushing the ends of the helix toward one another or extension by pulling the ends away from each other. The wound strip is also rigid enough against bending in a plane parallel to the axis to make it capable of supporting itself in a horizontal position. In some applications of my invention I find it convenient to use a device with the axis of the strip horizontal.

The stiffness is more than that corresponding to the natural stiffness of the material. The corrugations and their position at a small angle to the radius add stiffness to the structure.

After the helix has been made, all of it except the tabs 4 and 6 is coated preferably with a mixture of carbonates of barium and strontium, which coating changes during the usual treatment of the tube to a mixture of the oxides of said metals. Before this is done, the inner surface of the cylinder 2 is coated with an electron-emissive material like that on the strip, the coating extending from a location adjacent the upper end of the helix to one adjacent the lower end. An uncoated portion of the inner surface on the cylinder 2 extends beyond the helix in each direction.

The leads 7 and 5 constitute anchorages by which the ends of the helix are held stationary. They are welded or otherwise connected to the tabs 4 and 6.

The material for the shields 8 must have good reflecting properties and the innermost shield 2 must not so react with the material with which it is coated, even at high temperature as to diminish the thermionic activity. Nickel is found to answer these requirements well. The shields are secured in place by mounting them upon the bottom shield 20 and the cover shield 15 is secured to the supports 13. The cathode is then ready to be mounted in the tube 25 and the tube is completed by the usual heating, pumping, etc. A small quantity of mercury vapor or other ionizable gas such as neon, argon, etc. is left in the tube when the pumping is finished. The device in operation is connected into any suitable or usual rectifier circuit. The heating current is preferably alternating and of the same frequency as the current to be rectified. It is introduced into the cathode by connections to the terminals of the leads 7 and 24. The anode is connected through the terminal 27 and the usual circuit to the source of current to be rectified. The lead 24 acts as the other connection to the rectifier circuit. The phase relationships are so chosen that at the time the connection to the anode-terminal 27 is positive the connection to the lead 7 is also positive.

While the device is conductive, that is, while the anode is positive, the electrons which constitute the space current emerge from the inner surface of cylinder 2 and from the strip 1 and move to the anode. The space current circuit is over the lead 24 and the electrons which emerge from the cathode are returned to it over this lead. The electrons emitted from the cylinder 2 constitute a portion of the space current and the strip 1 is thus relieved from conducting that portion of the space current.

Since the area of the coated surface of the cylinder 2 is of the same order of magnitude as the area of the coated strip, the space current

carried by the strip is reduced by an important amount, namely the amount corresponding to the emission of the coated surface of the cylinder 2. The heating effect of the space current in the strip 2 is thus reduced to an amount such that undesirable overheating is unlikely even at the end 4 where the strip carries most current.

The strip 1 and the surface 11 emit electrons, the strip having been heated by the current flowing therein and the cylinder 2 by radiation from the strip 1. Although the heating current flows through the cylinder 2, the cross section of said cylinder is sufficient to carry this current without much heating. The shield therefore, is not heated to any substantial amount by the heating current.

The heat radiated by the strip 1 is absorbed by the coated portion 11 of the cylinder 2 and reradiated into the space containing the strip 1. Comparatively little radiation occurs from the outer surface of the cylinder 2 because it is a bright surface. It tends, therefore, to reflect any heat reaching it from the strip 1 back toward said strip. Similar reflections occur at each surface of each of the shields 8, except the inner surface of the shield 2. The combined effect of all the shields is to minimize loss of heat by radiation from the cathode.

It will be observed that electron emission occurs throughout a large surface including the corrugated surface of the strip 1 and the coated surface of the shield 2. Because the tube is gas-filled, the narrow spacer between corrugations or those between whorles of the helix emit electrons substantially as effectively as an unobstructed surface.

The same is not true of the heat radiated from such closely adjacent surfaces. The surface of the strip 1 is for the most part at a large angle to the direction in which radiation away from the helix must travel. The space occupied by the helix behaves very much like a "black body", the radiation therefrom being practically the same as the radiation from the cylinder which would be the envelope of the helix. This is at least approximately the same area as the inner surface of the shield 2 because the diameter of this shield exceeds the outer diameter of the helix by only enough distance to permit free movement of the electrons.

It will, therefore, be seen that practically all of the electron emissive coating is within the space which is shielded from radiation. The amount of heating required for a given amount of electron emission is materially diminished. By this arrangement, I find it possible to obtain the necessary electron emission with the temperature of the strip 1 exceeding the temperature of the inner surface of the cylinder 2 by less than 200° C.

Those skilled in the art will recognize that many variations in the details of this tube and of its method of manufacture, can be made without departing from the spirit of my invention. The omission of specific mention of such variations is not intended as a limitation.

I claim as my invention:

1. A cathode comprising a directly heated screw-shaped ribbon and a radiation shield surrounding said ribbon and heated by radiation therefrom, said ribbon and the inner surface of said shield being coated with electron-emissive material and the outer surface of said shield being bright.

2. A cathode comprising a screw-shaped ribbon, the ribbon being edgewise to the axis of the screw and a radiation shield surrounding said ribbon.

3. A cathode comprising a screw-shaped ribbon, the ribbon being edgewise to the axis of the screw and a radiation shield surrounding said ribbon, said ribbon and the inside surface of said shield being coated with electron-emissive material.

4. A cathode comprising a screw-shaped ribbon, the ribbon being edgewise to the axis of the screw and a cylindrical radiation shield surrounding said ribbon, said ribbon and the inside surface of said shield being coated with electron-emissive material and connections for heating said ribbon directly, said shield being heated by radiation from said ribbon.

5. A cathode comprising a corrugated ribbon in screw form, the corrugations extending across the ribbon at an angle to the axis of the screw.

6. A cathode comprising a corrugated ribbon in screw form, the corrugations extending across the ribbon at an angle to the axis of the screw and being of varying depth.

7. A cathode comprising a corrugated ribbon in screw form, the corrugations extending across the ribbon at an angle to the axis of the screw and being deeper at the inner edge of the ribbon than at the outer edge.

8. A cathode comprising a helical portion and a cylindrical portion surrounding the same, the equivalent radiation surface of the helical portion being approximately equal to the area of said cylindrical portion.

9. A cathode for electrical discharge devices comprising a corrugated, edgewise-wound, helical ribbon.

10. The method of forming a screw-shaped cathode which comprises corrugating a strip of cathode material with corrugation transverse to the strip, winding said corrugated strip edgewise into an approximately helical form and so distorting said corrugations during said winding that they are progressively more shallow from the inner to the outer edges of the strip.

11. The method for forming a screw-shaped cathode which comprises corrugating a strip of cathode material with corrugation transverse to the strip, winding said corrugated strip edgewise into an approximately helical form, so distorting said corrugation during said winding that they are progressively more shallow from the inner to the outer edges of the strip and coating the wound strip with an electron-emissive material.

12. A cathode comprising a corrugated ribbon in screw form, the corrugations extending across the ribbon at an angle to the axis of the screw and at an oblique angle to the edges of the ribbon.

ERWIN F. LOWRY.