Aug. 16, 1949. W. P. ZABEL 2,479,192

CATHODE

Filed June 28, 1946

Fig. 1.

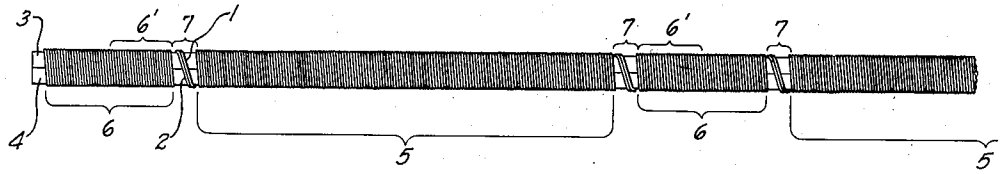
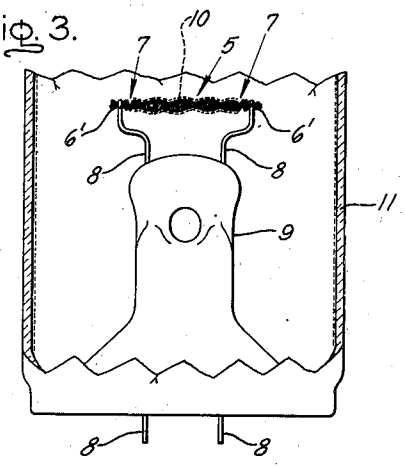



Fig. 2.




Fig. 3.




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## CATHODE

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3 Claims. (Cl. 250—27.5)

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My invention relates to electric discharge devices, and more particularly to cathodes for such devices and methods of manufacturing the cathodes.

It is an object of my invention to provide a cathode which is inexpensive and easy to manufacture and capable of being handled on automatic machines for fabrication into the electrode assemblies of electric discharge devices. It is also an object to provide cathode structures which have desirable electrical characteristics and are capable of retaining a copious supply of electron emissive material.

A feature of my invention is the manufacture of a cathode in the form of a helical coil composed of a plurality of wires coiled in parallel or side-by-side relation and provided with short auxiliary coiled ends spaced from the main body portion of the cathode by a turn or two of wide open pitch to form gaps in the coil. When the cathode is mounted by securing the auxiliary coiled ends to lead-in wires, the gaps serve to prevent the suspension of activating material (alkaline earth carbonates, for example) applied to the main body portion from traveling by capillary action beyond the gaps, thereby keeping it off the lead-in wires. The provision of the auxiliary coiled ends also serves to prevent the individual wires in the gaps from splaying out and tangling with other coils during handling. The said coiled ends also provide for a good connection to the hooks or clamps of the lead-in wires on which the cathode is supported.

According to another feature of my invention the coil is wound around a mandrel of oval or other flattened shape, preferably two or more mandrels of round wire extending side-by-side. It is thus assured that the individual wires of the multiple coil are retained in axial alignment.

Further features and advantages of my invention will appear from the following detailed description and from the drawing.

In the drawing, Fig. 1 is an elevation, greatly enlarged, illustrating a method of winding multiple or duplex coils according to my invention; Fig. 2 is an end view of a coil on the mandrels; and Fig. 3 is an elevation, partly in section, of an end of a discharge device containing a mount including a cathode and its supporting elements.

Referring to the drawing, the cathode coils are preferably wound continuously on automatic machinery by winding a pair of tungsten wires 1, 2 around a pair of steel mandrels 3, 4. The wires 1, 2 are wound with a closed pitch, that is with the adjacent turns touching. The longer lengths

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or segments 5 constitute the main body portions of the individual cathodes and are separated by shorter lengths 6 which are ultimately severed at their midpoints to constitute auxiliary end sections 6' spaced at 7 from the main body portions 5 by a turn or two of the wires 1, 2. The continuous wound coil-on-mandrel is heated to set the wires 1, 2 and is then severed at points midway of the segments 6. The mandrels 3, 4 are then dissolved in a suitable acid solution which results in a recoil of the turns of the coils to produce a corkscrew or spiral fluted contour as illustrated in Fig. 3.

After another heat treatment in which strains are completely removed and the wires are cleaned, the individual cathode coils are mounted by clamping the auxiliary end sections 6' in hook portions of lead-in wires 8 extending from a stem 9. The leads 8 are then spread apart a small distance to stretch the coil so that the turns of the pairs of wires 1, 2 are spaced apart a distance of approximately one mil while there is a hardly perceptible gap between the turns of the individual wires 1, 2.

The cathode coil is then provided with an activating coating or filling (indicated by dotted lines 10) by applying thereto a suspension of activating material such as alkaline earth carbonates (later broken down to oxides), the suspension being applied to the main body portion 5 of the coil, preferably by means of a trough-shaped applicator such as that disclosed in Patent 2,363,055, J. Flaws. The gaps 7 prevent the suspension from traveling by capillary action to the leads 8 and end coils 6'. This is highly desirable because any material deposited at those points is not properly processed upon passage of current through the coil to break down the carbonates to oxides and volatilize the usual binder, with the result that it evolves harmful gases into the bulb 11 of the electrical discharge device containing the cathode. It is for this reason that I prefer to clamp the coil in the leads 8 at the end sections 6' rather than at the gaps 7 although the latter practice may be followed if the gaps 7 are sufficiently long to insure a spacing of the end turns of the main body portion 5 from the leads 8.

It will be understood that the wires 1, 2 may be of different diameter or of the same diameter, and any desired number of wires (as many as seven, for example) may be used. Moreover, a single mandrel of round wire may be used in place of the two mandrels 3, 4 although I prefer the latter because the oval cross section of the

coil and its spiral fluted contour insures retention of the individual wires 1, 2 in axial alignment. Of course, a single mandrel of non-circular cross section, such as rectangular, may be used in place of two round mandrels. Also, the method of manufacture described above may be applied to a simple coil of one wire (instead of the plurality of wires 1, 2) to make coils comprising a main body section (like 5) having auxiliary end sections (like 6') spaced apart by gaps (like 7). It will further be understood that in place of plain wires 1, 2 I may employ continuous coils on mandrels, the said mandrels either being made of tungsten and retained in the finished cathode or being made of steel or molybdenum and dissolved out.

The cathodes described herein may be employed in the well known commercial fluorescent lamps which contain a few millimeters of gas (argon) and mercury, with a cathode at each end of the tubular bulb 11, the lamps being operated at currents of the order of 100 milliamperes to 1½ amperes with a mercury vapor pressure, during operation, of the order of 10 microns. Such a cathode may be composed, for example, of two tungsten wires 1, 2 of 2.3 mil diameter wound on two steel mandrels 3, 4 of 15 mil diameter each, the end segments 6' being 1.8 mm. long, the main body portion 5 being 10.4 mm. long, and the gaps 7 being ½ mm. long, the pitch being 215 turns per inch.

An alternative design which provides for fast starting of the arc discharge consists of three wires (corresponding to 1, 2) of 1.8 mil diameter wound simultaneously on a single 30 mil round mandrel. Similarly, three or more wires may be wound on an oval mandrel (two parallel round mandrels).

When using wires 1, 2 of different diameters a fine strand may be completely hidden by a coarser one by proper "nesting" of sizes. The result is a small helix secured within the diametrical limits of the larger one. Figuratively speaking, one coil is inside another, yet they are by no means telescoped or separable like a mechanically assembled coil within a coil.

Another advantage of the duplex or multiple type cathode disclosed herein lies in its different electrical characteristics from simple coils of one wire. For instance, with a given mandrel diameter, turn proximity, and cathode body length, a duplex or multiple wound cathode made from one size of small wire may have many more turns and grills and different mass than a single wire cathode of equivalent larger wire size having the same cold resistance.



What I claim as new and desire to secure by Letters Patent of the United States is:

1. A cathode comprising a multiple helical coil of a plurality of individual wires in side-by-side relation, said coil being of oval cross section and being longitudinally twisted to a spiral fluted contour and having integral auxiliary end sections spaced from the intermediate main body portion of the coil by portions of wide open pitch, the main body portion only being coated with electron emissive material.

2. A cathode comprising a multiple helical coil of a plurality of individual wires in side-by-side relation, said coil being of oval cross section and being longitudinally twisted to a spiral fluted contour and being coated with electron emissive material, the adjacent turns of the group of multiple wires being spaced apart approximately one mil and there being a hardly perceptible gap between the individual wires in the group.

3. A cathode comprising a multiple helical coil of a plurality of individual wires in side-by-side relation, said coil being of oval cross section and being longitudinally twisted to a spiral fluted contour and being coated with electron-emissive material.

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