May 18, 1943 J. G. W. MULDER 2,319,338

INCANDESCENT CATHODE

Filed April 9, 1941

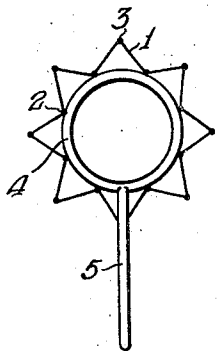


Fig. 1a

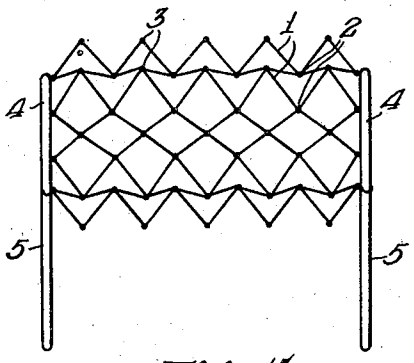


Fig. 1b

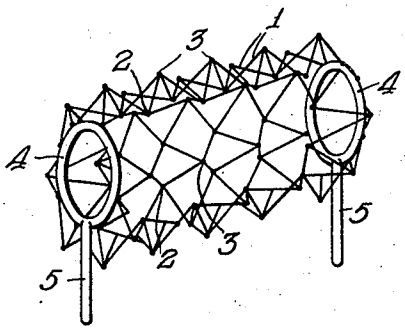


Fig. 2.

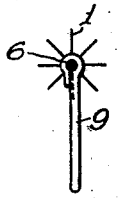


Fig. 3a

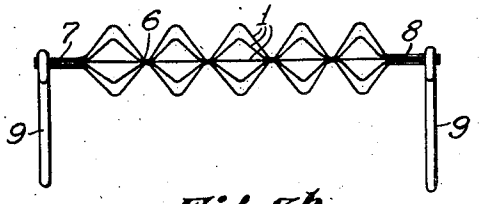


Fig. 3b

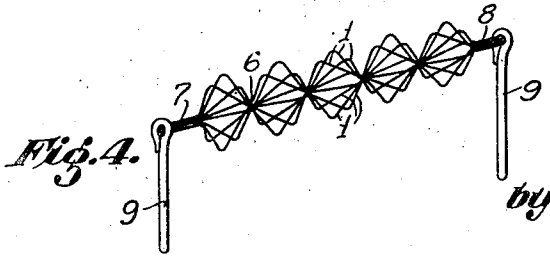


Fig. 4.

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# UNITED STATES PATENT OFFICE

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## INCANDESCENT CATHODE

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Application April 9, 1941, Serial No. 387,762
In the Netherlands March 27, 1940

7 Claims. (Cl. 250—27.5)

This invention relates to an incandescent cathode for use in gas- or vapour-filled discharge tubes for high current intensities and constituted by directly heated parallel-connected individual elements which are preferably arranged symmetrically with respect to an axis.

It has been suggested before that in gas- or vapour-filled discharge tubes use should be made of a plurality of parallel-connected individual cathodes. The great difficulty with such cathodes resides in that uniform distribution of the emission current over the entire cathode surface can generally be obtained with difficulty only since particularly at comparatively high gas- or vapour-pressures, for example of the order of magnitude of 1 mm. of Hg or more, the discharge exhibits a tendency to concentration at given points of the activated surface. This has a bearing on the fact that a gas discharge which is concentrated on a part of the cathode brings about an intense local increase in temperature which in turn increases the emission so that the discharge will preferably stay at this point.

For the purpose of obviating this disadvantage the method had been adopted of connecting very short and thick cathode elements in parallel, for example in the manner described in U. S. Patent No. 2,058,690, issued October 28, 1936. In this case under consideration this involved the necessity of selecting a very low supply voltage, for example of 1 volt or less, at a very high supply current.

On the other hand, where it is attempted to increase the current emitting capacity of a single element type of cathode by increasing its dimensions, the disadvantage is brought about that the emitting surface only increases according to the square of the linear dimensions, whereas the volume, and thus the weight, of cathode material, increases according to the third power of the linear dimension. Thus, the manufacture of incandescent cathodes of high power whose fundamental element is constituted by a very thick helically wound wire of tungsten becomes unduly expensive, for example at an emission current of 60 amp. 77 times as expensive as in the case of an emission current of 6 amp.

The invention has for its object to provide a cathode whose active surface is formed by grouping of a plurality of equivalent component elements so that the size of the active surface is practically proportional to the weight of the cathode and the disadvantages of the well-known parallel cathodes, inter alia restriction to low supply voltages, is avoided.

For this purpose the parallel-cathode according to the invention is so constructed that the symmetrically arranged individual elements are conductively inter-connected at a plurality of equipotential points lying closely together so that at these points differences in heat and disparities in the emission load of the cathode are balanced, there being recessed between the elements open spaces which enable the discharge to penetrate into the interior of the foraminated cathode structure, said apertures being of the order of magnitude of at least 0.5 cm.

It is possible to make large cathodes of this construction for normal supply voltages up to the order of magnitude of three volts or more which exhibit a very uniform distribution of the emission current over the activated surface of the various cathode elements.

It is preferable that the above-mentioned conductive cross-connections should be formed by sintering-up of nickel, iron or some mixture of these or related metals. In a number of cases the advantage is thus also obtained that a layer is formed to which the emitting material adheres more readily than to the core wire, generally formed of a material having a high melting point, of the cathode elements. (In conjunction or not with this measure it may be advantageous to form the cross-connections by binding-off with thin refractory metal wire.)

For building up a cathode according to the invention we may start with advantage with separate elements or units of tungsten wire on which a covering, for example of wire of the same material or of nickel, is spun in known manner.

The manner referred to permits of composing cathodes for high current intensity of different values by arranging in parallel a corresponding number of unit elements in the manner described and providing them with cross-connections. In this case it is particularly advantageous to establish a series of normal emission-current strengths of incandescent cathodes of equal supply voltage, it being possible for the said current strengths to be a multiple of a given fundamental current strength which may be taken for consideration for a single unit element.

An advantageous construction is obtained by working the individual elements into a preferably symmetrical and braided body, the points of overcrossing of the wire-shaped elements being constructed as cross-connections in the manner before described.

The individual elements of the cathodes may constitute the sides of a hollow cylindrical or

star-shaped prismatic body. If the ratio between the section and length of this body is correctly chosen the discharge is not only admitted to the internal emitting surface through the apertures of the sides but also from the two ends.

As a form for the individual elements of the cathodes use may primarily be made of the zigzag form or the form of a flat wound (helical) spiral which permits of interworking the latter in the manner of lattice. By applying as before the above-mentioned cross-sections according to the invention, which also form mechanical connections, a particularly rigid aggregate is obtained.

It is, however, also possible to choose the construction such that the cathode has no internal space but the individual elements arranged in a star-shape are always readily accessible from without. For this purpose, these elements, which may also be formed by flat-wound helical spirals of metal wire or metal band, may be arranged in such manner that the successive loops or windings of each element jointly form a straight elongated body practically located in a single plane and are located each in itself in such manner in radial planes around a common axis that one row of apices of the individual zigzag loops or windings is arranged along the axis referred to and jointly with the corresponding rows of apices of the other elements in the axis forms a plurality of cross-connections so that a body of star-shaped section is produced which at its two ends is connected to the leading-in wires.

In order that the invention may be clearly understood and readily carried into effect it will now be described more fully with reference to the accompanying drawing, in which

Figs. 1 and 2 show a cathode in parallel-projection and axonometrically respectively whose zigzag elements jointly constitute a hollow prism of star-shaped section.

Figs. 3 and 4 show in an identical manner a cathode built up from similar elements which are arranged in a star-shaped manner along a common axis.

Figs. 1*a* and *b* show in two projections how individual zigzag elements **1** can be composed to form a hollow prismatic body whose sides are formed by the individual elements, whereas the adjoining elements of the individual zigzag loops are united alternatively on the inside (**2**) and on the outside (**3**) of the body by cross-connections which constitute the vertices of rectangular pyramids. At the two ends of the cathode construction the innermost points of connection are united with robust wire rings **4** which serve as leading-in conductors for the supply current which is supplied from the cathode supports **5**.

This cathode construction is illustrated axonometrically in Fig. 2.

Figs. 3*a* and *b* similarly show how a prismatic cathode of star-shaped profile can be formed by grouping a plurality of zigzag elements **1** in a star-shaped manner so that a row of apices **6** of these elements are caused to be located along a common longitudinal axis and are united by cross-connections in the manner described above, whereas the ends of the elements lie together in a bundle-shaped manner at **7** and **8** respectively and are jointly connected to the leading-in wires **9** for the cathode.

Fig. 4 shows the construction of Fig. 3 axonometrically.

Whereas the hollow construction shown in Figs. 1 to 2 is preferable for comparatively large cathodes, for example for hundreds of amperes, the simpler construction shown in Figs. 3 and 4 is particularly advisable for cathodes of comparatively smaller current intensities, for example for emission currents of 100 amp. or less.

As an example of an element of one of the above-described cathodes we may mention a zigzag tungsten wire whose diameter is 0.4 mm. and which is spun with a nickel wire of 0.15 mm. and is then bent into the form of a zigzag 68 mms. in length whose width is 5 mms. and with which the distance between two successive apices of the same side is 3 mms. A cathode which is built up from 10 of these elements in the manner shown in Figs. 3 to 4 and which is coated with an activating layer of barium oxide may be used for a mean rectified current of from 60 to 100 amp. at a maximum value of about 200 amp. and requires a filament energy of 32 volts×70 amp.

In the finished state the cathode according to the invention may be provided in well-known manner with a covering layer of nickel so as to facilitate the adhesion of the emitting oxide layer.

What I claim is:

1. An incandescible cathode in the form of an elongated body, comprising a large number of undulated wire-like elements distributed around the longitudinal axis of the body and extending in the direction thereof, adjacent elements being interconnected thermally and electrically at the tips of the undulations.

2. An incandescible cathode in the form of an elongated body, comprising a large number of undulated wire-like elements extending in the direction of the longitudinal axis of the body, the undulated portions lying in a plurality of planes substantially parallel to the axis of the body and adjacent elements being interconnected thermally and electrically at the tips of the undulations to form a cage-like structure.

3. An incandescible cathode in the form of an elongated body, comprising a large number of undulated wire-like elements distributed around the longitudinal axis of the body and extending in the direction thereof, adjacent elements being interconnected at the tips of the undulations to form a plurality of pyramidal elements arranged in the direction of the axis of the body, said pyramidal elements being distributed about the axis of the body and adjacent pyramidal elements being interconnected at their base portions.

4. An incandescible cathode in the form of an elongated body, comprising a large number of undulated wire-like elements distributed around the longitudinal axis of the body and extending in the direction thereof, adjacent elements being interconnected at the tips of the undulations to form a plurality of pyramidal frames arranged in the direction of the axis of the body, and adjacent pyramidal frames being interconnected at their base portions, said elements forming a large number of openings having a smallest dimension at least of the order of .5 centimeter.

5. An incandescible cathode in the form of an elongated body, comprising a large number of undulated wire-like elements extending in the direction of the longitudinal axis of the body and disposed in planes containing the said longitudinal axis, said elements being substantially uniformly distributed around the said longitudinal axis and being interconnected thermally and electrically at the tips of the undulations.

6. An incandescible cathode in the form of an elongated body, comprising a large number of undulated wire-like elements distributed about

the longitudinal axis of the body and extending in the direction thereof, and means comprising refractory metal wire-like elements thermally and electrically interconnecting the adjacent elements at the tips of the undulations.

7. An incandescible-cathode in the form of an elongated body, comprising a large number of undulated wire-like elements distributed about the longitudinal axis of the body and extending in the direction thereof, a covering conductor forming a spun-like covering sheathing over said wire elements, adjacent elements being interconnected thermally and electrically at the tips of the undulations.

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