Feb. 5, 1957 T. M. JACKSON 2,780,747

ELECTRIC DISCHARGE DEVICES

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FIG. 1.

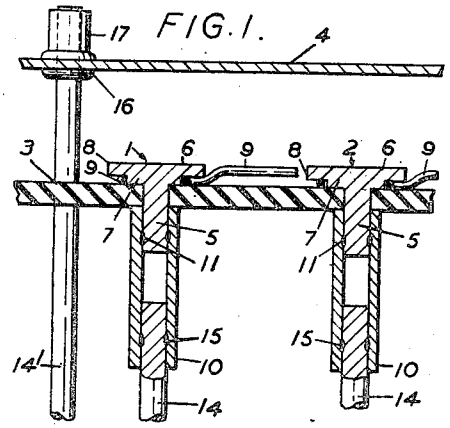


FIG. 2.

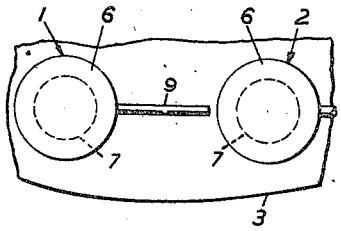


FIG. 3.

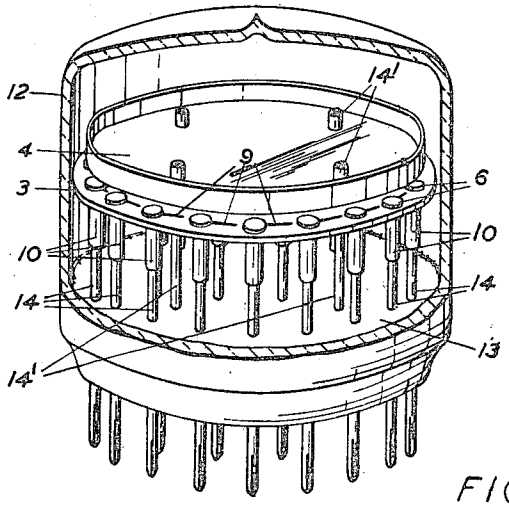
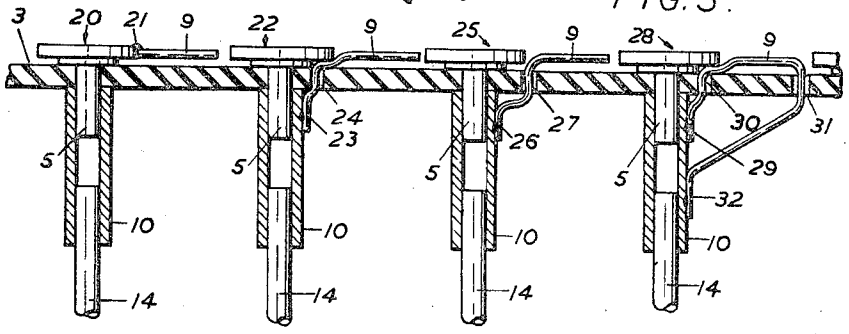


FIG. 5.



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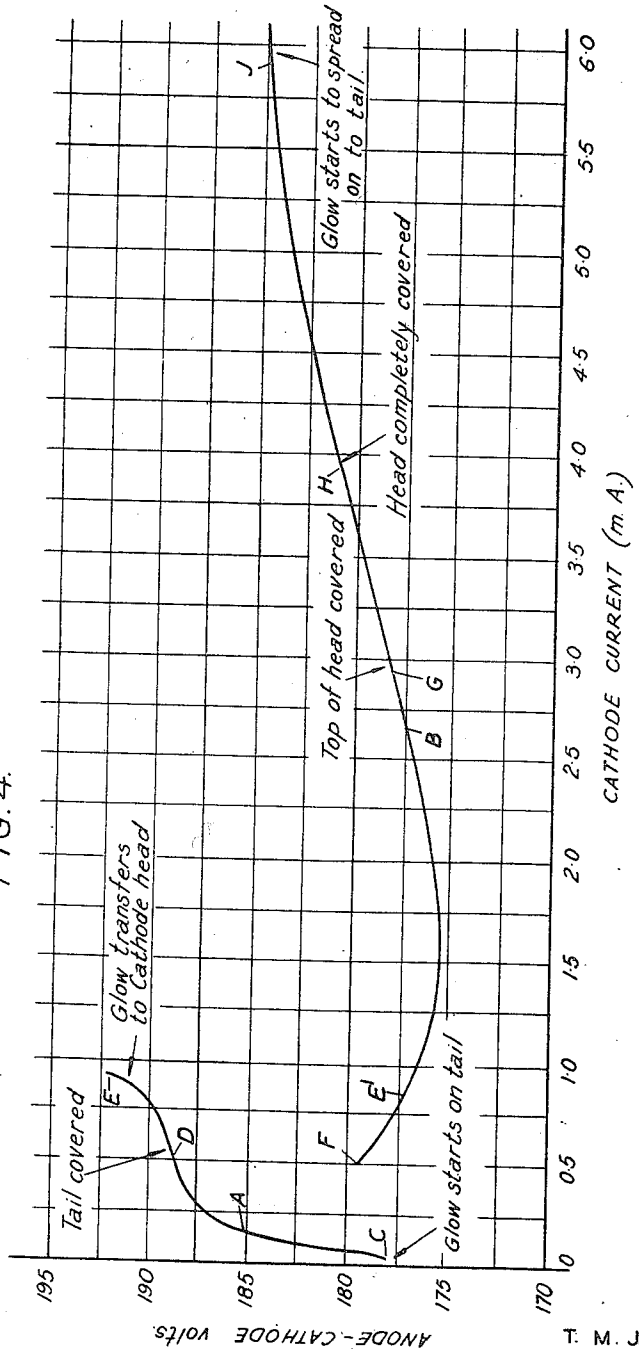
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FIG. 4.



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ELECTRICAL DISCHARGE DEVICES

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Claims priority, application Great Britain May 19, 1953

10 Claims. (Cl. 313—188)

The present invention relates to cold cathode electric glow discharge tubes and is particularly concerned with the construction of directional cathodes for such tubes.

In certain types of cold cathode electric glow discharge tube, electrode arrangements are provided by means of which it is possible in response to common input signals, to transfer a glow discharge from one of an array of discharge gaps to a second gap in the array to one side rather than the other, the transfer mechanism depending upon the reduction of striking potential of the second gap (due to the discharge at the first gap) being greater than the corresponding reduction of striking potential at the gap on the other side of the first gap. Such tubes are described and claimed in U. S. Patent No. 2,553,585 dated May 22, 1951 of G. H. Hough. In the constructions disclosed in that application, the direction of transfer of the discharge is determined by the shape of certain of the cathodes, the essential feature of the cathode shaping being that the directional cathodes should each comprise a portion of convenient shape, say a flat rectangle, parallel to a plane anode, at which cathode glow is positioned during intervals between successive transfer signals, together with a further portion of cathode in the form of a narrow ribbon-shaped member, usually referred to as a tail, the end of which is immediately adjacent the discharge gap from which the discharge is to be transferred onto the first mentioned portion of the cathode, referred to as the plate portion. During the transfer operation cathode glow commences at the end of the tail, spreads along the tail and then on to the plate. Due, primarily, to the large ratio of periphery to surface area of the tail portion as compared with the plate portion of the cathode, the maintaining potential for the anode to cathode-tail portion of the discharge gap is higher than that for the portion anode to cathode-plate. Therefore, once the glow has spread on to the cathode-plate, the discharge at the tail is extinguished and, as stated above, the glow remains on the plate portion but not upon the tail. In the practical embodiments described in the specification of the aforesaid U. S. Patent No. 2,553,585, these directional cathodes were constructed from metal strip, a portion of which was bent over parallel to the anode to provide the plate portion while the tail portion comprised an adjacent part of the strip edge-wise-on to the anode. The detailed construction of the complete discharge tube is in large measure determined by the particular construction of the directional cathodes.

According to the present invention there is provided a cathode in or for a cold cathode electric glow discharge tube comprising a head portion symmetrically shaped with respect to a given orientation mounted upon the end of a support wire and a slender tail portion projecting from and in substantially the same plane as, the head portions and in a direction normal to said given orientation.

The cathodes may be mounted upon an insulator by passing the support wire through a hole in the insulator

and fixing a tubular shank about the support wire so as to clamp the cathode to the insulator. It is preferred that the actual discharge surfaces of the cathode should be raised above the cathode support member by a distance of the order of the length of the cathode dark space, for which purpose a shoulder of appropriate height may be provided under the head portion of the cathode. An array of such cathodes may conveniently be mounted upon a single insulator and secured within a glass envelope by means of lead wires sealed in a glass base at one end and secured inside the respective said tubular shanks at the other.

The invention will be further described with reference to embodiments thereof shown in the accompanying drawings in which:

Fig. 1 shows in section an elevational view of part of a cathode assembly according to the invention together with a co-operating anode;

Fig. 2 shows a plan view of the cathode of Fig. 1;

Fig. 3 shows a discharge tube containing an anode and an array of cathodes according to the invention co-operating therewith;

Fig. 4 shows curves illustrating the electrical characteristics of a discharge gap using cathodes according to the present invention; and

Fig. 5 shows various modifications of the construction of the tail portion of the cathode of Fig. 1.

In Figs. 1 and 2 a cathode **1** and part of an adjacent cathode **2** are shown mounted upon an insulator **3** underneath a plane anode **4**. The main body of the cathode comprises a support wire **5** upon the end of which is formed a head portion **6**, and an underlying shoulder **7**. As shown in Figs. 1 and 2, the head portion **6** takes the form of a disc which, together with the shoulder **7**, can be formed in the same manner as the head of a wire nail, which, in fact, the cathode resembles. The shoulder **7** is completely overlapped by the periphery **8** of the head portion of the cathode and spaces the head portion above the surface of insulator **3** by a distance equal to the length of the cathode dark space when a discharge current causes the cathode glow on the head portion just to reach to the periphery. By this means glow is inhibited from spreading to the under-surface of the head portion and prevents any sputtering of cathode material on the surface of the insulator from enlarging in the course of the life of the tube, the area of the effective cathode discharge surface.

A fine wire cathode tail **9** is shown in Fig. 1 secured underneath and bent to lie substantially in the plane of the head portion **6** of cathode **1**, so as to project towards cathode **2**.

The cathodes are secured to the insulator **3** by means of tubular shanks **10**, surrounding, and welded to, the support wires **5** so as to clamp the cathodes in position in the insulator **3**.

The provision of the tubular shanks **10** affords a very convenient means of mounting a cathode array in a discharge tube envelope, an example being illustrated in Fig. 3, in which the envelope **12** comprises a glass base **13** through which leads **14** are sealed in conventional manner. The upper ends of these leads **14**, as shown in Fig. 1, are fittted into the ends of the respective tubular shanks **10**, and welded thereto, as indicated in Fig. 1 at **15**. The cathode assembly is thus firmly supported upon the base **13**. The anode **4** can be mounted in an analogous manner upon other of the lead wires **14**, of which one identified by the numeral **14'**, is shown in Fig. 1, passing through the insulator **3** and secured to the anode **4** by means of an eyelet **16** and collar **17**.

The tail portion **9** of Figs. 1 and 2 should project to within a distance equal to the length of the cathode dark space from the periphery of the cathode **2**. Dur-

ing operation, the cathode glow at cathode **2** is transferred to the tail portion **9** of cathode **1** and spreads therealong onto the head portion **6**, where it is maintained until the next input signal, the glow over the tail portion being extinguished as soon as the discharge reaches the head portion. Thus in Figs. 1 and 2 the cathode construction is such as to allow transfer of the glow discharge from cathode **2** to cathode **1** via the tail portion **9**, and in Fig. 3 the glow may be transferred from cathode to cathode clockwise along the array of cathodes.

Typical relationship between anode-cathode voltage and cathode current for a discharge gap formed as in Fig. 1 by a cathode **1** and anode **4** are indicated in the graphs of Fig. 4. The curve A refers to discharge at the tail portion alone and the curve B to discharge at the head portion of a cathode having the following essential dimensions:

	Inches
Diameter of head portion **6**	0.104
Thickness of head portion **6**	0.010
Thickness of shoulder **7**	0.005
Diameter of tail **9**	0.005
Length of tail (projecting beyond head)	0.120

If discharge be initiated, by means with which we are not immediately concerned, at the end of the cathode tail, the discharge current and anode-cathode voltage are given by the co-ordinates of the point C on curve A, the anode-cathode voltage being then about 178, and the current about 0.1 ma. As the discharge current increases, the anode-cathode volts increase rapidly until at point D cathode glow completely covers the tail. Further increase of cathode current involves an increase in anode-cathode voltage without corresponding spread of cathode glow until the point E is reached, when the glow transfers to the cathode head and the operating point to E′ on curve B. The voltage immediately drops by some 15 volts, becoming lower than the smallest voltage at which discharge to the tail can be maintained; the transfer of the discharge from tail to head is thus complete. If the discharge current be now reduced, the discharge characteristic follows the portion E′F of curve B. With increase of the discharge, as would normally occur, the characteristic to the right of E′ on curve B is followed. The curve shows a decrease of anode-cathode voltage to a minimum value, after which it increases again with increasing current until, at the point G, the glow covers the upper surface of the cathode head, and then commences to spread down the sides of the head until, at H. the glow covers the whole upper surface and side of the head. Due to the small clearance above the insulator **3**, further spread of glow below the head is prevented. With still further increase of current, now exceeding the maximum design current, the voltage continues to rise until at the point J the glow spreads once more onto the tail portion **9**.

In the manufacture of a cathode assembly according to the invention, we find it convenient to secure a rather longer length of fine wire than is required to form a cathode tail **9** onto the main body of the cathode, and to shape and cut the fine wire to the required length after the several cathodes have been secured in position on the insulator **3**. A spacing jig is positioned beneath the shoulders of two adjacent cathodes, and the cathode tail **9** is bent to the required shape against the jig before being cut off to leave the correct spacing between the tail portion and the adjacent cathode.

In Fig. 1 the cathode tail is shown secured beneath the head portion **6** of the cathode. Various modifications to this method of fixing are shown in Fig. 5, which depicts part of an array of cathodes, all having some different modifications. Thus the left-hand cathode **20** has its tail **9** formed of a straight length of fine wire welded directly to the head portion of the cathode as indicated at **21**. In the adjacent cathode **22** the tail

9 is secured to the shank **10**, as indicated at **23**, and passes through an extension **24** of the aperture in the insulator **3** through which the cathode support wire **5** is passed. Cathode **25** has its tail portion welded at **26** to the shank **10**, but taken out through a separate aperture **27** in the insulator **3** before being bent over. A further modification is shown to the right of Fig. 5 in which cathode **28** has a tail portion formed from a loop of fine wire, one end of which is welded to the shank **10** at **29**, and passes through an aperture **30**, in similar manner to the arrangement of cathode **22**, but the tail, instead of being cut off adjacent the next cathode in the array, is bent to pass through a further aperture **31** in the insulator **3**, and is welded again to the shank **10** at **32**, thus ensuring that the fine wire is not liable to be displaced from its correct position during assembly of the discharge tube or subsequent transport thereof.

While the present invention has been described with particular reference to a multi-cathode tube, in which discharge is transferred along an array of cathodes in one direction, there are circuit applications for which the mechanism of the transfer operation is itself valuable, and a cathode according to the present invention may usefully be incorporated in a tube having, for example, only a single pair of discharge gaps.

While the principles of the invention have been described above in connection with specific embodiments, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What I claim is:

1. In a cold cathode electric glow discharge tube, a cathode having a head portion, a support wire on which said head portion is mounted and a slender tail portion projecting from and extending in substantially the same plane as the head portion, a plane cathode-supporting member and means for mounting the head portion above said supporting member by a distance substantially equal to the length of the cathode dark space.

2. A tube according to claim 1 in which the said head portion is a disc formed on the said support wire in similar manner to the head of a wire nail.

3. A tube according to claim 1 in which said means comprises a shoulder integral with the head portion, said shoulder resting on the plane surface of the supporting member, with the periphery of the head completely overlapping the shoulder and spaced from the said surface, said supporting member having an aperture through which the support wire projects.

4. A tube according to claim 3 further comprising a tubular shank surrounding and secured to the said support wire underneath the said insulator member so that the cathode is clamped in position.

5. A tube according to claim 4 in which the said tail portion is a straight length of fine wire secured to the said head portion.

6. A tube according to claim 4 in which the said tail portion is a fine wire secured to the underside of the said head portion and is formed to project parallel to, and spaced from, the said surface.

7. A tube according to claim 4 in which the said tail portion is a fine wire secured to the said tubular shank and formed to project parallel to, and spaced from, the said surface.

8. A tube according to claim 4 in which the said tail portion is a fine wire projecting through an aperture in the said insulator separate from the aperture receiving the said support wire and is bent at right angles above the insulator surface to project parallel thereto and spaced therefrom.

9. A tube according to claim 4 in which the said tail portion is a fine wire loop secured to the said tubular shank and passing through spaced-apart apertures in the

said insulator between which the said fine wire is parallel to and spaced from the said surface.

10. A cold cathode electric glow discharge tube comprising an array of cathodes according to claim 4 mounted upon a common said insulator, the said array and insulator being secured to a glass envelope base by means of lead wires sealed through the base of the tube envelope and secured in respective said tubular shanks.

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