Oct. 31, 1950 | G. H. HOUGH ET AL | 2,527,552

ELECTRIC DISCHARGE TUBE

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FIG. 1.

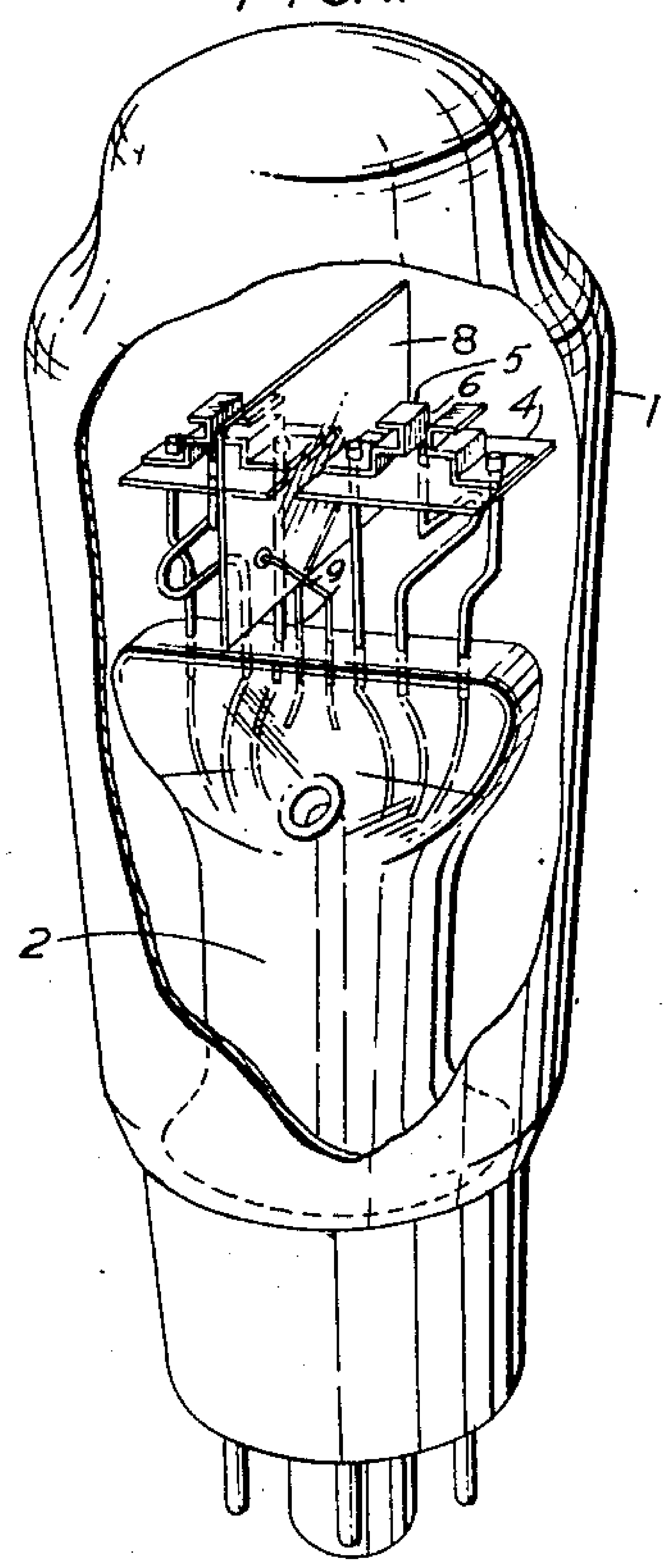


FIG. 2.

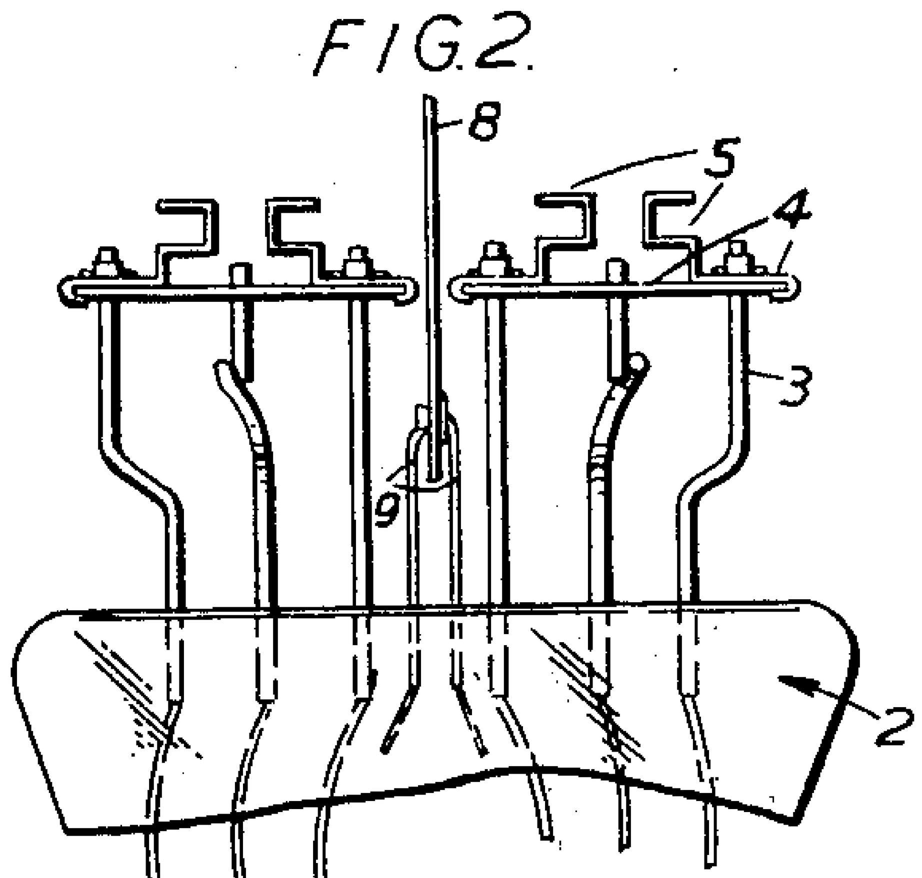


FIG. 3.

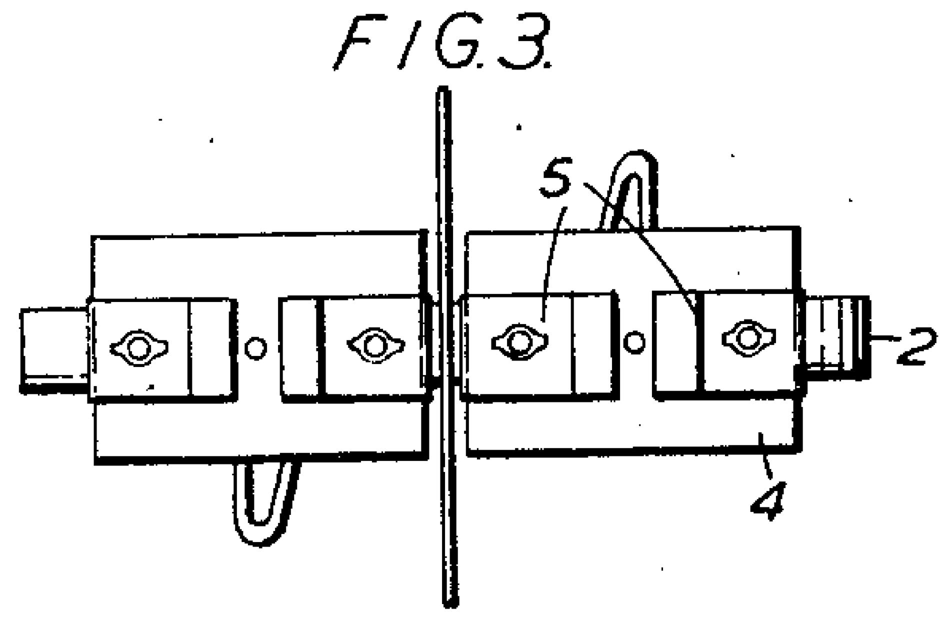
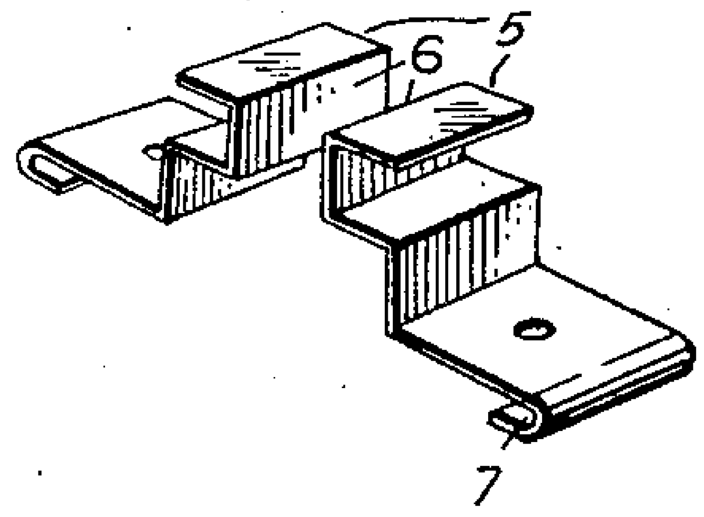


FIG. 4.



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ELECTRIC DISCHARGE TUBE

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10 Claims. (Cl. 250—27.5)

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The present invention relates to cold cathode electric discharge tubes and is particularly concerned with the construction of a tube in which discharge at an auxiliary gap primes or triggers a discharge at the main gap.

According to the present invention there is provided a three-electrode discharge gap assembly for a cold cathode electric discharge tube comprising a pair of electrode plates mounted on a sheet of insulating material, the said plates having substantially parallel opposed discharge gap surfaces at right angles to and separated from said sheet, and a third, auxiliary, electrode protruding through an aperture in said sheet beneath said plates.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a discharge tube according to the present invention;

Fig. 2 is a diagrammatic side elevational view of a gap assembly of a discharge tube according to the present invention;

Fig. 3 is a plan view corresponding to Fig. 2; and

Fig. 4 shows a preferred construction of the discharge surfaces of the main anode and cathode electrodes.

In the construction of electric discharge tubes for pulse operation we have found that constancy of operation and long life render it desirable that the surface of cathode electrodes shall be well defined and that steps be taken to prevent sputtering of the cathode material onto neighboring parts extending the effective cathode area or otherwise affecting the operation of the tube. As shown in Figs. 1 and 2, the electrode assembly, which is assembled inside the glass envelope **1**, is mounted upon a conventional glass press **2**. The tube shown accommodates a double assembly, both assemblies being similar and each comprising three nickel rods **3**, sealed into the press **2**, a mica plate **4** and main discharge electrodes **5**. The centre rod of the three nickel rods **3** may be used either as a cathode or an anode trigger, as will be discussed below, the other two forming lead out connections for the anode and cathode of the main discharge gap. The mica plate **4** passes over the ends of the rods, so as to leave a small area of each protruding above the surface. The main gap is provided by the electrode plates **5** which are formed from flat sheets with upturned channel section edges **6**, (Fig. 4) the channel recesses facing the flat portion of the plate so as to provide a pair of extended rectangular surfaces opposed to one another to form the

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gap. The two main electrode plates are mounted on the mica plate **4** and riveted thereto in conventional manner. In order to maintain accurate gap dimensions it is preferred that the outer edges **7** (Fig. 4) of the plates be turned under to position them with respect to the edge of the mica sheet. The electrode plates assembled on the mica sheet can then readily be plated over and welded to the outer pair of rods **3**, so that the latter support the mica plate. The upturned channel section edges forming the main discharge gap surfaces are raised above the flat portion of the electrode plates as shown in Fig. 2, thereby ensuring that negligible amounts of cathode material are sputtered onto the supporting mica sheet to form possible extensions of the cathode discharge surface.

The use of cold cathode trigger tubes is well known but the principles of operation are not so generally understood. In some known types of tube an annular cathode of large surface area is provided together with a centrally disposed anode in the form of a rod or wire. The auxiliary trigger gap is then provided by means of a further rod or wire placed closer to the cathode than the main anode and hence having a lower striking voltage than the main gap. The cathode electrode frequently has an activated surface of low work function, but in cases where the cathode is unactivated it is possible to reverse the polarity of the electrodes in circuit so that the electrode normally the cathode is made the anode. The device would then, however, exhibit very different characteristics. When once a discharge has been established between two electrodes, most of the voltage drop across the discharge gap is concentrated in the cathode dark space, the voltage drop across this region being known as the cathode fall. So long as cathode glow does not cover the whole of the cathode surface, the cathode fall tends to remain constant in voltage and physical length; in the region of abnormal glow—when the whole of the cathode surface is covered with glow—the cathode dark space tends to contract with increasing current and the voltage across the gap rises above that for normal glow conditions. It will be appreciated, that the conditions for triggering the main gap by means of an auxiliary anode or an auxiliary cathode are quite different, apart from any asymmetry of the main gap electrodes. Furthermore, if an auxiliary anode is used, since the cathode fall has already been established at the cathode of the main gap when the trigger gap is discharging, the main discharge may be struck practically instantaneously. In the case of a cathodic trigger, cathode glow occurs around the trigger electrode and priming of the main discharge gap is largely effected by migration of charged particles from the region of the cathode glow; there is thus an inevitable time lag—which may last from 4 to 5 μ secs.—before the priming of the main gap is effected. Furthermore the build up of discharge in the main gap—i. e., the rate of rise of current—is in any case determined to a large extent by the field existing across it, the configuration being different for the two cases of anodic and cathodic triggering. The difference, though insignificant for low speed working, is of importance and should not be neglected in a design for high speed working. In devices according to the present invention a symmetrical gap system is chosen so that the difference in rise of main gap current for cathodic or anodic triggering is a minimum.

The construction so far described, besides being simple to manufacture, has accurately defined main and trigger gap dimensions. The main gap electrodes being symmetrical in shape and all electrodes being of the same material, the construction is very suitable for use with the trigger electrode connected either as an anode or as a cathode. In the latter case a further constructional feature, which may readily be incorporated, may be desirable.

In the case of cathodic triggers it is generally desirable that the auxiliary gap should be worked under abnormal glow conditions or at least with glow covering most of the cathode surface; the latter, therefore, should be small and accurately defined. We have found, as described in the copending application of G. H. Hough and L. C. Baker, bearing Serial No. 90,316 filed April 29, 1949, that if a collar of metallic or of insulating material is placed around a cathode to clear the same but by less than the length of the cathode fall, cathode flow is inhibited from spreading through the collar. It will be evident that the mica plate **4** may be made to fulfil this purpose and it may then be referred to as a field control plate. Under abnormal glow conditions, as stated above, the cathode fall contracts but we have found that even though for somewhat excessive currents the glow may tend to spread through the aperture about the trigger electrode, the plate is effective from the point of view of operational stability for most conditions likely to be met in practice. If the trigger electrode is only to be used as an anode, the mica plate does not serve any controlling function, under normal operating conditions.

For many purposes, such, for example as in a crystal control oscillator it is convenient to mount two discharge gap assemblies such as described in one envelope. In order to prevent ionisation coupling between the discharge gaps of one assembly from interfering with the operation of the other, we have found that it is sufficient to insert between the two a sheet of insulating material, such as mica, as shown at **8**. The sheet **8** may conveniently be supported by means of rods **9** sealed into the glass press **2**.

The dimensioning of the gap assembly depends upon the operating conditions required together with the electrode materials and gas filling of the tube. For a tube using pure nickel electrodes in a gas mixture containing hydrogen or a partial pressure of 35 m. m. of mercury and neon (with 1% argon) at a partial pressure of 5 m. m. of mercury, and required to operate under pulse conditions with a repetition frequency of 100 kc./s., we find that a gap length of 1 m. m. for both main and auxiliary gaps is satisfactory. In a typical tube the rods **3** were approximately 1.0 m. m. diameter, the centre aperture of the plates **4** (for cathodic trigger operating) was 1.27 m. m. diameter, leaving 0.15 m. m. for the centre rods protruding above their respective surfaces, while the main discharge surfaces of the plate **5** were 2 x 5 m. m.

With the construction of a discharge tube according to the present invention there is no necessity to treat any surfaces to prevent unwanted discharges occurring thereat. This is particularly advantageous as it is found that coatings on cathodes tend to be destroyed by cathode sputtering, which in the present tube by design is comparatively innocuous thus allowing very much longer tube life. Furthermore the construction is very simple and follows conventional vacuum tube technique.

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 is claimed is:

1. An electric discharge device comprising an envelope enclosing a non-conductive member having an aperture therein, a pair of mutually insulated electrodes having flat symmetrically shaped opposing surfaces positioned on one side of said member and defining a discharge gap, and an auxiliary electrode protruding through said aperture but not into the gap defined by said surfaces.

2. A cold cathode electric discharge device comprising a gas filled envelope, an electrode structure mounted within said envelope and including a non-conductive member having an aperture therein, first and second electrodes having flat symmetrically shaped opposing surfaces positioned on one side of said member and defining a discharge gap therebetween, and a third electrode protruding through said aperture but disposed outside said discharge gap.

3. A cold cathode gas filled electric discharge device comprising an envelope enclosing a non-conductive member, a pair of electrodes attached to said member and having substantially parallel opposed rectangular surfaces positioned on one side of said member, said surfaces forming a main discharge gap therebetween, and an auxiliary electrode extending from said one side of the insulating member towards but not within said main discharge gap.

4. A device according to claim 2 wherein said third electrode is spaced an equal distance from said first and said second electrodes and constitutes a trigger electrode for initiating the discharge across the gap defined by said opposing surfaces.

5. A device according to claim 4 wherein said trigger electrode comprises a metal rod.

6. A device according to claim 2 wherein there is further provided three support rods for mounting respectively said first, second and third electrodes.

7. An electric discharge device comprising an envelope enclosing an apertured flat member, a first electrode protruding through said aperture on one side of said member, mutually insulated second and third electrodes each having a portion substantially parallel with said member and an upturned portion, said upturned portions

having symmetrically shaped opposed surfaces raised above the protruding end of said third electrode said surfaces defining a discharge gap therebetween.

8. A device according to claim 7 wherein said first electrode constitutes a cathode trigger electrode spaced from said member within said aperture a distance less than the normal cathode fall, said cathode trigger electrode spaced an equal distance from said second and said third electrodes.

9. An electric discharge device comprising a gas filled envelope enclosing a flat non-conducting member, a pair of rectangular electrodes each having a portion parallel with said member and attached thereto and an upturned channel-shaped end portion said end portions having opposed rectangular surfaces raised from said member, and an auxiliary electrode extending from said member towards but not within the gap defined by said opposed surfaces.

10. Electric discharge tube comprising a gas filled envelope, at least six electrode lead-out rods sealed substantially in a line in a glass press within said envelope, a pair of mica sheets apertured to pass over the first three and the last three rods respectively of said line, a pair of rectangular metal plates secured to each of said sheets and to the first and third of the respective three rods, the plates of each pair of plates having opposed upturned edges providing a pair of rectangular surfaces closer together than adjacent said rods, said surfaces forming a discharge gap vertically above the end of the second of the respective three rods and forming therewith a trigger discharge gap, and a sheet of insulating material mounted between said mica sheets to inhibit ionisation coupling between the gap assemblies.

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