Oct. 12, 1948. A. R. MOORE 2,451,297

RUGGED GASEOUS DISCHARGE TRIODES

Filed Aug. 1, 1944

Fig. 1.

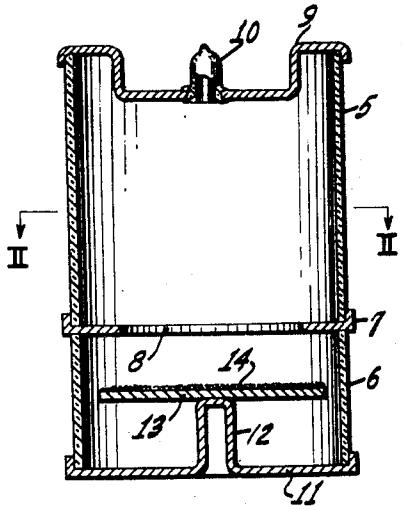


Fig. 3.

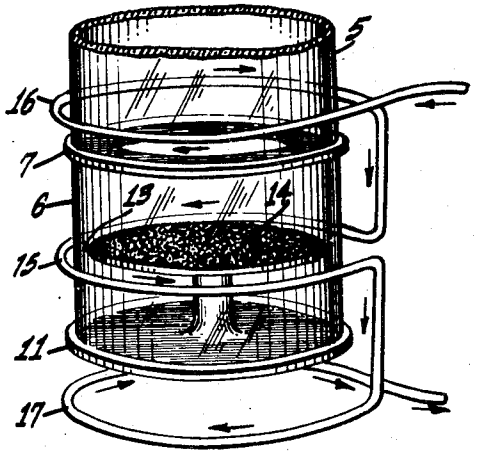
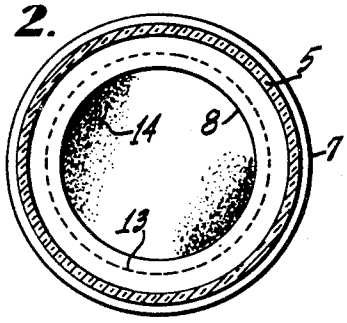


Fig. 2.



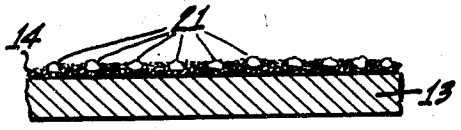
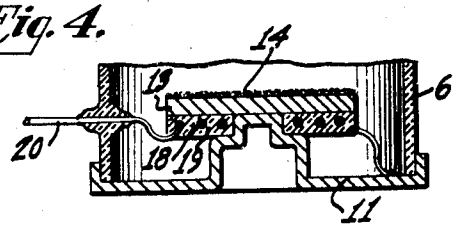


Fig. 5.

Fig. 4.



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Patented Oct. 12, 1948

2,451,297

UNITED STATES PATENT OFFICE

2,451,297

RUGGED GASEOUS DISCHARGE TRIODES

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Application August 1, 1944, Serial No. 547,618

2 Claims. (Cl. 250—27.5)

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My invention relates to electron discharge devices and more particularly to controlled gaseous discharge devices having a cold cathode and a control electrode, and to methods of manufacture of such devices.

Controlled gaseous discharge tubes of simple and rugged construction and in which the discharge is started by a comparatively slight change in the voltage in the control electrode are needed for some purposes as relay or trigger type tubes. In some cases the tubes are subjected to severe transverse and longitudinal shocks. Controlled gaseous discharge tubes of the conventional construction do not have sufficient mechanical strength to withstand such severe usage without damage and change in the electrical characteristics of the tube.

The principal object of my invention is to provide a very rugged gaseous discharge tube which will withstand very severe shocks, such as those due to a very high rate of acceleration, without distortion or mechanical failure of the parts and without changes in the operating characteristics of the tube. A further object is to provide a tube of this type in which the discharge will start in response to a comparatively slight change in voltage on the control electrode even though the change of voltage applied to the control electrode is great. Another object is to provide for gaseous discharge tubes a cold cathode of the oxide coated type which is especially useful in making a gaseous discharge more easily started and more dependable than is the case with cold cathodes heretofore used. Another object is to provide a method of heat treating and processing the cold cathode without overheating and injuring the glass-to-metal seals of the tube.

My invention will best be understood by reference to the accompanying drawing in which merely for purposes of illustration I have shown one form of tube embodying my invention and in which—

Fig. 1 is a longitudinal section of a controlled gaseous discharge tube constructed in accordance with my invention;

Fig. 2 is a cross-section on the line 2—2 of Fig. 1 showing the relation of the annular control grid to the cathode;

Fig. 3 is a schematic illustration of an induction heating apparatus by means of which I practice my improved method of heating and processing the oxide coated cold cathode without injuring the glass-to-metal seals of the control electrode and of the end cap;

Fig. 4 is a cross-section of a portion of the

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cathode and of the tube showing a modified form of cathode with a resistance type of heater for use during processing; and

Fig. 5 is a cross-section on a greatly enlarged scale of a part of the preferred form of cold cathode having a coating which facilitates the starting and maintaining of the gaseous discharge in the tube.

The tube shown in Fig. 1 resembles in appearance a cartridge fuse and consists essentially of a tubular glass envelope closed at the ends by metal caps which are hermetically sealed to the ends of the glass tube and constitute closures for it. The envelope contains an ionizable gas or atmosphere, such as argon, neon, or mixtures thereof, usually at a pressure from 1 mm. to 50 mm. of mercury. In the specific embodiment of my invention shown in Fig. 1, the glass envelope consists of two sections 5 and 6 of the same size of glass tubing arranged coaxially and end to end, with the adjacent ends sealed by glass-to-metal seals to the flat sides of a sheet metal washer 7 which is thus embedded in and firmly supported by the glass walls of the envelope with its outer edge exposed to permit electrical connections to be made to it. In the specific form of tube illustrated this washer-type control electrode has concentric with the tube envelope an opening 8 somewhat less in diameter than the envelope, so that the inner edge of the control electrode projects radially into the envelope to the extent necessary to give the desired control. The two tubular glass sections with their abutting ends sealed to the flat annular control electrode form a very strong and rugged envelope wall in which the control electrode is rigidly held against displacement.

Each end of the tubular glass portion of the envelope is closed by a metal cap sealed to the glass. In the particular form illustrated a metal cap 9 at the upper end of the tube may constitute or support an anode, and for convenience may have an exhaust tube 10, preferably of metal, which is hermetically sealed after the tube is exhausted. The other or lower end of the envelope is closed by a similar metal cap 11, which may constitute or support a foundation for an oxide coated cathode, and which preferably has a central pedestal 12 projecting upwardly and into the interior of the tube. The cold cathode illustrated as an example consists of a cathode foundation 13, usually a rigid disc of nickel somewhat larger than the opening 8 of the control electrode, firmly affixed to the inner end of the pedestal 12 as, for example, by welding, and thus

very firmly supported on the end cap 11. The surface of the rigid metal cathode foundation facing the other or upper end of the tube is rendered electron emissive in known ways, preferably by a thin adherent coating 14 of alkaline earth oxides, such as the barium and strontium oxide coating generally used on conventional oxide coated thermionic cathodes. The coated or electron emitting surface of the cathode is thus directly exposed through the opening 8 of the control electrode to the anode. The metal end caps 9 and 11 are of metal which will make a good glass-to-metal seal with the glass of the envelope, such as the chrome-iron alloys commercially used for sealing to glass.

During manufacture of the tube the cathode foundation 13, coated with a layer of barium and strontium carbonates, must be heated to about 1000° C. in order to convert the carbonates into oxides and to form on the surface of the cathode foundation an activated oxide coating 14 having high electron emmissivity at temperatures of about 700° C. to 800° C. A convenient way of heating the cathode disc 13 is by high frequency induction, but if the conventional high frequency coil is used to heat the disc cathode, the annular control electrode 7 and the metal cap 11 are coupled to the field of the heating coil to such an extent that they are liable to be heated so high that the seal between the glass and metal is impaired. In accordance with my invention impairment of the seals during heating of the cathode may be avoided by a method of heating which may conveniently be practiced with the apparatus best shown in Fig. 3 and in which the cathode foundation 13 may be heated by a high frequency induction heating coil to the desired temperature while at the same time those parts of the high frequency field of the heating coil which are coupled to the control electrode 7 and the cap 11 are counteracted or neutralized in the vicinity of both the control electrode and the cathode cap 11 to such an extent that the control electrode and the metal cap are not heated high enough to impair their seals to the glass. The high frequency induction heating apparatus illustrated as an example comprises in effect three parallel coaxial pancake-type coils shown as single turn coils connected in series with the intermediate coil wound opposite to the two parallel end coils. The three coils are spaced, as shown in Fig. 3, so that when the cathode heating coil 15 is placed in the plane of and around the disc cathode, so that its field is well coupled to the cathode foundation 13, the two other or end coils 16 and 17 wound oppositely to the heating coil are on opposite sides of the heating coil 15, one beyond the ring grid 7, and the other beyond the metal cap 11. The three pancake coils are substantially coaxial and are wound about their common axis with the turns of the end coils 16 and 17 so wound that, as indicated by the arrows, the direction of current flow in the heating coil 15 is opposite to the direction of current flow in both end coils 16 and 17. With this arrangement, and with the three coils connected in series, the end coils 16 and 17 produce two synchronous high frequency fields which oppose and overlap to a large extent the field of the heating coil 15 on opposite sides of the cathode, and largely counteract or neutralize the effect of the heating coil 15 in the region of the annular control electrode 7 and of the end cap 11 which are in the two zones where the opposing fields overlap. As a result, the control electrode 7 and the end cap 11 remain much cooler than the cathode foundation 13, which is closely coupled to the heating coil 15.

The cathode foundation 13 may also be heated during exhaust of the tube without overheating the glass-to-metal seals of the tube by a heating coil 18 of the resistance type in heating relation to and insulated from the lower side of the cathode foundation, as, for example, by being embedded in insulation 19. Current is supplied to the coil 18 through a lead 20 to one end of the coil and the end cap to which the other end of the coil 18 is connected. After processing the cathode, this resistance heater has served its purpose and it may be permanently disconnected.

I have found that in accordance with my invention starting and maintenance of the discharge is greatly facilitated by mingling with the barium and strontium oxides of the oxide coating some finely powdered inorganic insulation which is inert at any temperature attained by the cathode during processing or operation of the tube. As indicated in Figure 5, these particles 21 of insulation in or on the oxide coating are more or less uniformly distributed throughout the coating, with many of them on the surface of the coating. While the exact mode of operation of such a cathode is not definitely understood, I have found that the presence of these fine particles of inorganic insulation facilitate starting and maintaining of the discharge. In a tube of this type in order to obtain the desired output, which may be as high as three or four amperes, the discharge which starts as a glow discharge should change to an arc in order to take advantage of the low voltage drop which accompanies the arc discharge. The transition from the glow discharge to the arc discharge was found to be facilitated by the incorporation into the cathode spray material of small particles of inorganic insulation amounting to from 5% to 10% by weight of the spray material. The preferred inorganic insulation is finely powdered quartz composed of particles from 3 microns to 10 microns in diameter. For example, I have used with success a mixture of .0058 gram of powdered quartz per gram of mixed barium and strontium carbonates. The powdered quartz should be a minor constituent of the coating and may to advantage be from about 5% to 10% by weight of the spray material or about 8% to 15% by weight of the barium and strontium oxides which constitute the cathode coating. This amount of powdered quartz will provide on the average about 3½ particles of quartz per square millimeter of oxide coated cathode surface.

A convenient size of tube constructed in accordance with my invention is one in which the tubular envelope is approximately one-half inch in diameter and about an inch long with the annular ring or control electrode 7 spaced from the anode a distance of about two-thirds of the length of the tube bulb and the oxide coated disc cathode spaced about one-fourth of that distance from the control electrode.

The glass-to-metal seals to the control electrode 7 and the end caps 9 and 11 may be made in various ways but conveniently by a high frequency induction coil which surrounds the tube in the plane of the seal so that its field heats the metal and the adjoining glass to sealing temperature.

I claim:

1. A controllable gaseous discharge tube com-

prising a cylindrical glass envelope containing gas at low pressure, a metal cap sealed to and hermetically closing each end of said envelope, one of said caps having a central pedestal projecting into said envelope and extending above the plane of the glass-to-metal seal of said cap, a flat oxide coated cathode comprising a flat rigid metal disc affixed to the inner end of said pedestal and extending substantially parallel to said cap and a coating of alkaline earth metal oxide on the side of said disc exposed to the other cap with fine particles of quartz distributed through and on the surface of said coating, and a control electrode comprising a metal ring embedded in the wall of said envelope and projecting into the interior of said envelope with its inner edge between said cathode and the other end of said envelope.

2. In a gaseous discharge tube comprising a cylindrical glass envelope containing a low pressure ionizable atmosphere, and a metal cap at each end of said envelope constituting a closure for said envelope, a flat cathode comprising a rigid sheet metal foundation affixed directly to

one of said caps and directly exposed to and facing the other cap, and a coating on the side of said foundation exposed to the other cap comprising a mixture of alkaline earth metal oxides and finely powdered quartz constituting about 8% to 15% by weight of the mixture.

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