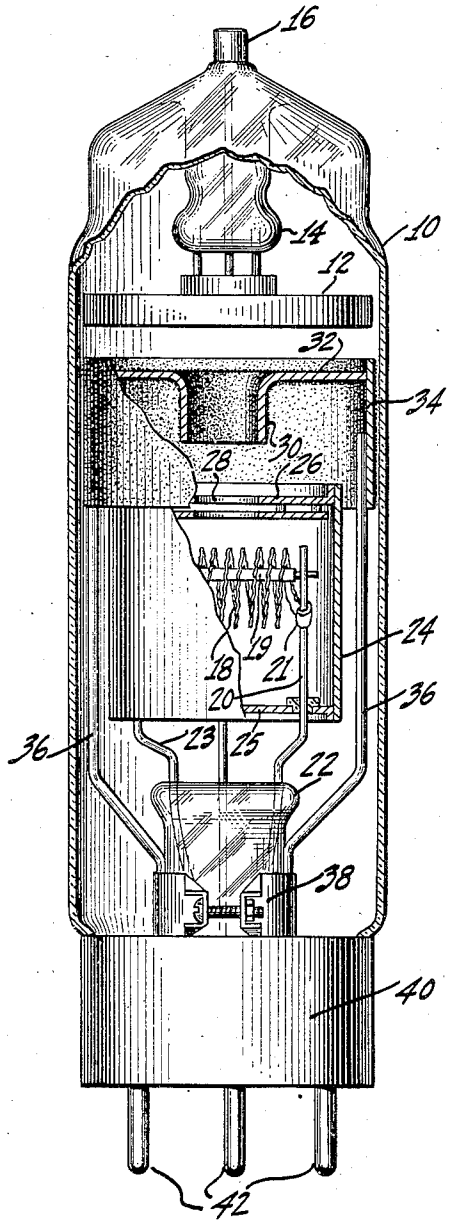
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CONTROL GRID FOR GAS TUBES

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CONTROL GRID FOR GAS TUBES

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My invention relates to a gas control tube and more particularly to a grid controlled gas tube.

One type of thyratron gas tube employs a filamentary cathode electrode, an anode electrode and a control electrode or grid mounted between the anode and cathode electrodes. In operation, a difference of potential is established between the anode and cathode electrodes to produce an electron discharge therebetween. The tube is filled preferably with a monatomic gas to amplify the primary discharge between the cathode and anode electrodes. The average amount of current conducted by this type of tube can be varied within limits by the control grid electrode. A negative bias, more negative than a critical value, placed upon the control grid will prevent an effective electron emission from the cathode so that no current is conducted by the tube. If the potential of the grid electrode is shifted so that it becomes more positive than the critical value, an electron discharge takes place between the cathode and anode electrodes sufficient to cause gas ionization. Under this condition the tube breaks down and there is current flow in the form of an arc discharge between the cathode and anode electrodes. At this point, the control electrode loses control of the tube and cannot stop the tube discharge even if the grid potential is shifted below the critical value. That is, a sufficiently negatively biased grid electrode can control the starting of the tube discharge but cannot control the tube discharge, once it has begun. In the usual application of this type of tube, a bias, below the critical value, is normally maintained on the grid electrode. Means are provided to shift the grid bias above the critical value to permit tube conduction at any scheduled time.

During the operation of this type of tube, several undesirable conditions are established which cause an unscheduled discharge of the tube. Due to these conditions a charge is built up on the grid electrode sufficient to cause a shift in grid potential to a point above the critical value at which an unscheduled discharge of the tube takes place.

One condition causing such a shift in grid characteristic is a deposition from the cathode of sputtered or evaporated materials, mainly barium upon the grid electrode. The deposited material causes a change in the contact potential of the grid electrode which brings about a slow steady change of a few volts in the grid characteristic throughout the life of the tube. This grid shift may be counteracted by adjusting the grid bias voltage to maintain a desired average current passing through the tube.

Another condition causing a shifting grid characteristic is a primary electron emission from the grid. This primary grid emission depends upon the operating temperature of the control

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electrode, its base material and the amount of material deposited thereon from the cathode. Such grid emission causes rapid changes in grid potential in which within a few minutes time the grid bias voltage may have to be doubled, tripled or the control grid may lose control entirely.

As it is desirable that a tube have a stable characteristic, it has been found more expedient to eliminate the causes of a shifting grid characteristic than to compensate for the shift by adjusting the grid bias voltage.

It is therefore an object of my invention to provide a gas control tube having an improved operation. It is also an object of my invention to provide a grid controlled gas tube having a substantially constant grid voltage breakdown characteristic.

It is also an object of my invention to provide a grid controlled gas tube in which the change in contact potential during tube life is minimized.

It is also an object of my invention to provide a grid controlled tube in which primary emission from the grid is effectively reduced.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying, in which:

The figure discloses a longitudinal view partially in section of the tube, according to my invention.

The gas control tube comprises an envelope 10 enclosing a plurality of electrodes. An anode electrode 12 in the shape of a circular plate structure is supported from the top of the tube envelope by a depending stem structure 14. Appropriate leads pass through the stem or press 14 and through the glass envelope 10 to an anode terminal contact 16. The cathode 18 is constructed as a corrugated ribbon bent in a circular spiral and is supported by the edges of the ribbon on a ceramic rod 19. The cathode ribbon 18 is also a filament which is fixed to leads connecting the cathode to an appropriate source of electrical energy. The drawing shows a support rod 20 to which the horizontal ceramic rod 19 is fixed. Rod 20 is mounted in the glass press 22 of the envelope. One end of the filamentary cathode 18 is fixed, such as by welding, at 21 to the support rod 20. The rod 20 has an extension passing through the glass stem 22 and connected, as is well known in the art, to a metal base pin 42.

Another support rod, a portion 23 of which is shown in the drawing, supports the other end of the ceramic 19 and also forms an electrical lead to the other end of the filamentary cathode 18. The cathode ribbon 18 is covered, as is well known in the art, with an electron emitting material composed mainly of the oxides of barium

and strontium. Surrounding the filamentary cathode is a heat shield 24 which is principally a cylinder mounted coaxially with the circular anode 12. The heat shield 24 may be closed at the bottom by a circular plate 25. The upper end of the cylindrical heat shield is closed by a plate 26 having an aperture 28 at its center. The aperture 28 is preferably a circular opening coaxial with the cylinder 24 and the anode 12. The opening 28 provides a path for a discharge between the filamentary cathode 18 and the anode electrode 12. The purpose of the heat shield structure 24 is mainly to prevent the escape by radiation of the heat energy from the cathode 18. The shield, thus, maintains the cathode heat more or less in the localized space around the cathode, and permits the use of a smaller filament current. Furthermore, the shields 25 and 26 prevent large dissipation of heat to the other parts of the tube which permits these tube parts to be maintained at a lower temperature during tube operation.

Mounted between the anode electrode 12 and the filamentary cathode 18 is a tubular grid structure 30. This grid structure comprises an electrode for controlling the discharge between the anode and cathode electrodes. The control grid tube 30 is mounted coaxial and in alignment with the heat shield aperture 28 and the cathode plate 12. The tubular control member 30 is supported at the center of an annular plate 32. The annular plate 32 in turn is mounted at its periphery to the inner surface of a cylindrical skirt structure 34. Side rods 36 support the cylindrical member 34 on the glass stem 22. The supporting side rods 36 may be fixed to the stem 22 by a metal collar 38 tightly clamped around the base of the press 22. One of the support rods 36 may form an electrical lead between the control grid 30 and one of the base leads 42.

An appropriate current passed through the filamentary cathode 18 heats it to a temperature at which there is a copious emission of electrons from the cathode surface. When a difference of potential is established between the anode 12 and the cathode 18 in a manner such that the anode 12 is positive and the cathode is negative, there will be an electron flow from the cathode 18 to the anode 12. In tubes of this type, it is desirable to amplify this electron discharge by providing a gaseous medium within the tube. After tube evacuation, a monatomic gas is forced into the tube under a predetermined pressure. The pressure of the gas within the tube is not particularly critical and any of the inert gases such as krypton, xenon, or argon may be used. The electron discharge between the cathode 18 and anode 12 ionizes the gaseous medium to increase the amount of current flowing through the tube. This electrical discharge between the cathode 18 and anode 12 is confined in a path passing through aperture 28 and the tubular control grid 30.

In the operation of this type of tube, an alternating potential is maintained between the anode plate 12 and the cathode 18. As the anode is essentially a cold non-electron emitting electrode, the tube will conduct a current only during the half cycle when the anode 12 is positive. A negative bias potential is placed on the tubular grid electrode 30. This grid bias potential is sufficiently negative to prevent any effective electron emission from the cathode 18. When the potential of the control grid 30 is shifted in a positive direction, a critical value of the grid potential will be reached beyond which an electron discharge will take place between the cathode 18 and the anode 12. The control grid potential may be shifted in the positive direction by any desirable method. However, the operation of this tube is such that once an arc discharge is established between the anode 12 and cathode 18, the grid 30 loses control of the tube. That is, if after the tube discharge is established, the bias of the control electrode is shifted negatively below the critical value, the discharge or conduction of the tube is not effected. The control electrode 30 thus merely controls the starting of the tube discharge at any desired point in the half cycle in which the anode 12 is positive. The discharge of the tube can be stopped by removing the positive potential on the anode as is done when the potential of anode 12 becomes zero at the end of its positive half cycle.

The practical application of such a tube is usually as a control device for operating some desired mechanism such as a relay in response to a small shift of electrical potential applied to the control grid 30.

A major problem in thyratrons of this type is that of a shifting grid characteristic. I have found that during operation, the tube will discharge or conduct at unscheduled times. I have found that such an uncontrolled action of the tube is due to several causes.

One cause is an unstable grid control in which the grid potential changes rather slowly. This shift of grid potential may be counteracted by adjustment of the grid bias voltage. However, this is not always possible nor convenient during the operation of the tube. It is more desirable that the tube have a stable characteristic, one which does not require any adjustment during the life of the tube. I have found that this comparatively slow grid shift is due to a change in the contact potential of the grid electrode. This is brought about by the evaporation or sputtering of the electron emissive material from the filamentary cathode. During tube operation the cathode 18 is heated to a relatively high temperature which causes considerable thermal agitation. Furthermore, the excessive electron emission from the cathode as well as the bombardment of the negative cathode by positive gas ions will cause the throwing off of particles of the electron emissive material covering the cathode filament. These particles of electron emissive material pass out in all directions and are deposited upon the parts of the control grid 30 which are in alignment with the cathode filament 18 through the aperture 28. The deposit of the electron emissive material upon the surfaces of the grid electrode 30—32 will cause a change in the contact potential of the grid. This is caused mainly by the reaction of the barium of the emissive material with the base material of the control electrode. The result is that a charge is built up on the control electrode 30 which tends to counteract the grid bias voltage applied to this electrode. Making the grid bias voltage more negative will temporarily restore the operating characteristics of the tube.

A second cause of the loss of tube control by the grid is an unpredictable, erratic and often a rapid shift in grid voltage brought about by a primary electron emission from the grid. This deleterious primary grid emission produces gas ionization within the tube and results in an uncontrolled discharge between the anode and cathode electrodes. As the tubular control electrode 30 surrounds a considerable portion of the path of the

arc discharge of the tube, it becomes heated to a relatively high temperature by the arc. During tube operation then, the control electrode **30** and its supporting plate **32** comprise a hot electrode which is maintained at a large negative potential relative to the positive anode plate **12**. Under these conditions sufficient primary electron emission takes place from the control electrode **30** and its supporting plate **32**. Furthermore, the electron emissive material sputtered over onto the control electrode surfaces from the cathode **18** also provide a source of primary electron emission. This primary grid emission emanating from the deposited material upon the control electrode increases considerably as the temperature of the control grid becomes unduly high.

As shown in the figure, I have designed a new type of grid structure which will eliminate the outstanding causes of a shifting grid characteristic as fully outlined above. I have constructed my grid tube **30**, the supporting plate **32** and cylinder **34** of rapid heat-conductive copper material. Furthermore, the skirt structure **34** is spaced close to the glass wall of the envelope **10**. This arrangement provides a radiating means for dissipating the heat energy derived by the control grid from the arc discharge of the tube. The copper tubular grid **30** and supporting plate **32** are a highly conductive means for transferring heat energy from the relatively hot tube portion **30** to the radiator **34**. The radiating cylinder **34** is made as large as possible to provide a sufficiently large radiating surface. In this manner, the heat energy absorbed by the tubular grid **30** is carried away as far as possible from the path of the arc discharge.

Furthermore, to increase the heat dissipating surface of the radiator **34**, I coat the surfaces of the cylinder **34** with powdered zirconium metal sintered to the surface of the cylinder. This zirconium metal surface is applied in a manner to provide a roughened surface area which greatly increases the radiating surface of the cylinder. Also, the zirconium metal coating as deposited upon the control radiator **34** results in a dark covering which further aids in heat dissipation.

I have further found that by covering the surfaces of the control tube **30** and the supporting plate **32** with a powdered zirconium metal, that the shift in grid potential, due to change of contact potential of the grid is minimized. It isn't entirely clear just what reaction takes place between the powdered zirconium metal coating and the deposited electron emissive material, but it may be possible that the zirconium metal forms an amalgam with the barium deposited upon the control electrode surfaces. The barium may be absorbed by the zirconium in such a way that it is relatively ineffective in changing the contact potential of the control electrode.

Furthermore, the application of a zirconium metal coating to the grid electrode effectively inhibits the primary emission caused by the presence of sputtered electron emissive material on the control grid surfaces. Also, the primary grid emission is reduced by the particular construction of the grid electrode which permits lower operating temperatures.

Discharge tubes constructed according to the above described design have been tested and found to have an extremely stable grid characteristic. A grid structure made of a highly heat conductive material as copper and provided with a radiator having a greatly increased heat dissipating surface area permits a much lower operating temperature for the control electrode. Furthermore, the shift in grid characteristic caused by the change in contact potential of the grid and caused by the primary electron emission from the grid is greatly reduced by the powdered zirconium coating.

In constructing the grid structure disclosed in the figure, parts **30** and **32** may be made separately or integrally as a single piece. The periphery of the annular plate **32** may be joined by welding or other means to the inner surface of a copper cylinder **34**. The figure shows plate **32** mounted near the tube of the radiating cylinder **34**. However, this particular arrangement is not limiting as it is conceivable that plate **32** may be mounted at the center or even at the lower end of the cylindrical heat radiator **34**. The copper grid structure **30—32—34** may then be cleaned in any conventional way such as by acid cleaning, hydrogen firing, vacuum firing, etc. The copper part after cleaning is then sprayed with a zirconium hydride powder which has been mixed with a suitable liquid binder and carrier. The amount of spray per square centimeter of the copper grid part may be varied a great deal without causing appreciable variation in the results obtained. I have found that 3 to 4 milligrams per square centimeter is adequate. After spraying, the copper grid part is air dried. The next step then is to vacuum fire the grid part. During this process, the zirconium hydride is changed to zirconium metal, the binder material is driven off and if the temperature is sufficiently high the zirconium particles will sinter to the copper grid surface. This process provides a dark roughened metal surface over the copper grid. The zirconium will sinter to the copper between 830° and 875° C. although these temperatures are not critical, as sintering will take place at lower or higher temperatures and at correspondingly different periods of time. It is not strictly necessary that the zirconium be sintered to the copper grid surface, since I have found that most of the benefits derived from a grid with zirconium metal sintered to its surface can also be obtained if the zirconium is not sintered to the copper metal. After the zirconium hydride has been reduced and the zirconium metal particles are preferably sintered to the copper grid electrode, the grid part may be mounted with the other electrodes in the envelope **10** and the tube given a convenient exhaust.

While certain specific embodiments have been illustrated and described, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What I claim as new is:

1. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode spaced within said envelope from said anode electrode, and an apertured control electrode mounted between said anode and cathode electrodes for the passage of a discharge between said anode and cathode electrodes, a sheet metal element fixed to the control electrode for radiating heat therefrom, and finely divided metal particles sintered to said metal element to increase the heat radiating surface thereof.

2. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode spaced within said

envelope from said anode electrode, and a copper control grid plate axially aligned between said anode and cathode electrodes, said grid plate having an aperture at the center thereof, a skirt element fixed to the periphery of said grid plate for radiating heat therefrom, finely divided metal particles sintered to said skirt element to increase the heat radiating surfaces thereof.

3. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode spaced within said envelope from said anode electrode, and a control electrode mounted between said anode and cathode electrodes, said control electrode including a circular copper control grid plate axially aligned between said anode and cathode electrodes and having an aperture at the center thereof, the edges of said aperture extended as a tube coaxial with said annular grid plate to provide a passage for an arc discharge between said anode and cathode electrodes, finely divided zirconium metal sintered to the surfaces of said grid plate and said tubular aperture, a copper cylinder coaxially fixed to the periphery of said circular grid plate for radiating heat therefrom, and finely divided metal particles sintered to said cylinder to increase the heat radiating surface thereof.

4. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode, spaced within said envelope from said anode electrode, and a control electrode mounted between said anode and cathode electrodes, said control electrode including a copper disc axially aligned with said anode and cathode electrodes, said disc having an aperture at the center thereof, a metal tubular member extending coaxially from the apertured center of said disc to provide an arc discharge passage between said anode and cathode electrodes, a copper cylinder coaxially fixed to the periphery of said control electrode disc for radiating heat therefrom, and finely divided zirconium metal particles sintered to said cylinder to increase the heat radiating surface thereof.

5. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode spaced within said envelope from said anode electrode, a circular copper control grid plate axially aligned with said anode and cathode electrodes, a copper tubular member extending coaxially from the surface of said grid plate and forming an aperture therethrough to provide an arc discharge passage between said anode and cathode electrodes, zirconium metal particles sintered to the surfaces of said grid plate and tubular member, a copper

cylinder coaxially fixed to the periphery of said control grid plate for radiating heat therefrom, and finely divided zirconium metal particles sintered to said cylinder to increase the heat radiating surface thereof.

6. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode spaced within said envelope from said anode electrode, a copper tubular control grid member axially aligned between said anode and cathode electrodes to provide a passage for an arc discharge between said anode and cathode electrodes, a circular copper plate supporting said tubular control grid, finely divided zirconium metal particles sintered to said tubular control grid member and said supporting plate, a copper cylinder mounted within said envelope coaxial to said tubular grid member, said supporting plate fixed at its periphery to the inner surface of said cylinder whereby said supporting plate will conduct heat during normal tube operation from said tubular grid to said copper cylinder, and zirconium metal particles sintered to the surfaces of said copper cylinder to increase the heat radiating surface thereof.

7. An electron discharge device comprising a sealed envelope, a gaseous medium within said envelope, an anode electrode mounted within said envelope, a cathode electrode spaced within said envelope from said anode electrode, said cathode electrode including a surface covered with a material of high electron emissivity, a control grid including a tubular member providing a passage for an arc discharge between said anode and cathode electrodes, powdered zirconium metal sintered to the surface of said tubular control member to prevent electron emission from electron emissive material sputtered onto said tubular member from said cathode electrode, a circular copper plate supporting said tubular control grid for conducting heat therefrom, a copper cylinder mounted within said envelope coaxial to said tubular grid member, said supporting plate fixed at its periphery to the inner surface of said cylinder whereby said supporting plate will conduct heat during normal tube operation from said tubular grid to said copper cylinder, and zirconium metal particles sintered to the surfaces of said copper cylinder to increase the heat radiating surface thereof.

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