

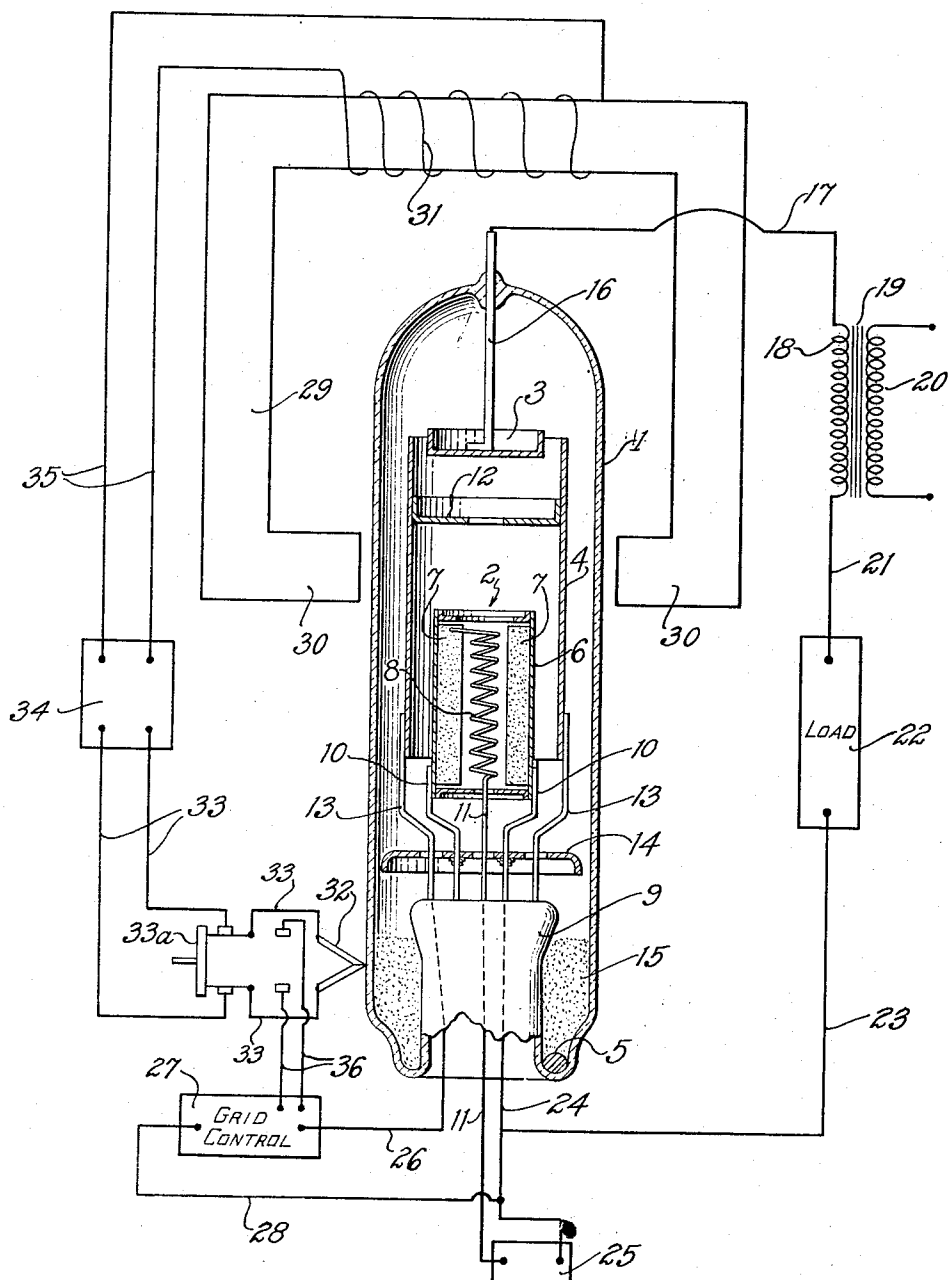
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TEMPERATURE COMPENSATED CONTROLLED GASEOUS DISCHARGE TUBE

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TEMPERATURE COMPENSATED CONTROLLED GASEOUS DISCHARGE TUBE

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This invention relates to a temperature-compensated controlled gaseous discharge tube.

In controlled gas-filled electrical discharge tubes in which the time of initiation of the discharge is controlled by means of a control element, ambient temperature variations produce changes in the gas pressure within the tube, and as a result change the operating characteristics of the tube. This is particularly pronounced in vapor-filled tubes inasmuch as the vapor pressure varies rapidly with changes in temperature.

An object of this invention is to compensate for the variations in control characteristics, due to changes in temperature, which are produced in such controlled gaseous discharge tubes.

Another object is to accomplish this result by the use of a magnetic field.

A further object is to accomplish these results by the use of a magnetic field and an electrostatic field.

The foregoing and other objects of my invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein the diagrammatic figure represents a cross-section of a controlled gaseous discharge tube and an associated circuit embodying one form of my invention.

In the drawing, the controlled gaseous discharge tube consists of a sealed glass envelope 1 containing a thermionic cathode 2, an anode 3, and a control electrode 4. The envelope 1 is filled with an ionizable medium, preferably mercury vapor, supplied from a drop of mercury 5. The tube is preferably operated with mercury vapor pressures between 1 and 100 microns, although pressures outside of this region may likewise be used. It is to be understood that the envelope 1 may be filled with other vapors or gases at sufficiently high pressures so that when a discharge passes, ionization occurs and a current flows between the cathode and anode at relatively low voltage drops.

The cathode 2 may consist of a hollow metal member 6 containing a plurality of internal radial fins 7. The interiors of the member 6 and the fins 7 are coated with a suitable electron emissive material, such as, for example, the alkaline earth oxides. The coated surfaces of the cathode are raised to temperature of thermionic emission by means of an internal heater 8, the upper end of which may be welded to one of the fins 7 and the lower end of which may be connected to the heater lead 11. The cathode is supported on a reentrant stem 9 formed in the

envelope 1. The cathode is supported on said stem 9 by means of a pair of cathode support standards 10, one of which is sealed through the stem 9 to provide an external electrical connection to the cathode. The heater lead 11 is likewise sealed through the stem 9 to provide an external electrical connection.

The control electrode 4 is preferably provided with a partition 12 having a center opening therein through which the discharge may pass between the cathode 2 and the anode 3. The control electrode 4 is also supported on the stem 9 by means of a pair of standards 13, one of which is sealed through the stem 9 to provide an external electrical connection to the control electrode. In order that the lower portion of the envelope 1 be kept cool so that the mercury vapor may condense therein, a radiation shield 14 supported on the standards 10 is interposed between the cathode 2 and the stem 9. The anode 3 is supported within the envelope 1 by means of an anode standard 16 sealed through the upper end of said envelope.

In order to supply the tube with energy, a lead 17 connects the anode lead 16 to one end of the secondary winding 18 of the power transformer 19. The transformer 19 is provided with a primary 20 which may be connected to some suitable source of alternating current. The other end of the secondary 18 is connected by means of a lead 21 to one terminal of a load device 22. The other terminal of the load device 22 is connected by means of a conductor 23 to the cathode lead-in wire 24 which is connected to one of the cathode standards 10. The two conductors 24 and 11 are connected to a suitable source of heater current 25 which thus supplies the heater 8 with current to raise the temperature of the cathode 2 to a point at which its coated surfaces emit electrons thermionically.

In order to supply the control electrode 4 with a control voltage, a lead 26 connects one of the standards 13 to one terminal of a source of control voltage 27. The other terminal of said source 27 is connected by means of a conductor 28 back to the conductor 24 and thus to the cathode 2.

When the various sources of potential described above are energized, the tube is set in operation. Under these conditions, when the anode 3 becomes positive with respect to the cathode 2, a discharge will be initiated and current will flow through the load 22. If the control electrode 4, however, has a control voltage which is usually negative with respect to the cathode impressed

upon it at the time the anode 3 becomes positive, the initiation of the discharge is delayed until the voltage on the control electrode 4 falls to a predetermined minimum value which is less negative with respect to the cathode. Under most conditions this minimum value may be slightly negative. The grid control device 27 may be adjusted to supply various control voltages to the control electrode 4, and in this way regulate or control the value of the current flowing through the load device 22.

When the tube is operating as described above, the mercury vapor will condense at some region within the envelope 1, which in the case described above will consist of the lower region 15 as indicated as a shaded region in the lower part of said envelope. The vapor pressure within the envelope 1, therefore, will be determined by the temperature of the portion 15. As this temperature rises and the vapor pressure rises, it will be found that the voltage on the control electrode 4 must be made more negative in order to prevent the initiation of the discharge at any positive value of voltage impressed upon the anode 3. Thus changes in the ambient temperature of the envelope 1 will produce changes in the operating characteristics of the tube.

I have found that if a transverse magnetic field is impressed upon the tube intermediate the cathode 2 and the anode 3 within the control electrode 4, such a transverse magnetic field will enable the control electrode 4 to prevent the initiation of a discharge at any positive value of voltage applied to the anode 3, with a smaller negative voltage applied to said control electrode 4. By impressing upon the tube such a transverse magnetic field which varies in accordance with the temperature, the variations in the characteristic of the control electrode 4 with temperature as described above may be compensated, and the operating characteristic of the tube may be maintained substantially constant. In order to impress such a transverse magnetic field upon the tube, I provide a magnetic core 28 having a pair of pole pieces 30 placed adjacent the envelope 1 in the region of the control electrode 4 so as to set up a transverse magnetic field within said control electrode 4. The core 28 may be energized from a suitable energizing coil 31. In order to supply the coil 31 with a current which varies in accordance with the temperature, a thermo-couple 32 is held adjacent the envelope 1 at the region 15. The output of the thermo-couple 32 is connected by means of a pair of leads 33 through a switch 33a to the relay device 34. The output of the relay device 34 may be connected by means of a pair of conductors 35 to energize coil 31. The relay device 34 may consist of a relay or amplifying device which will supply to the coil 31 a current which varies in accordance with the value of the current or voltage generated by the thermo-couple 32. In actual practice the coil 31 may be wound so as to produce the required value of transverse magnetic flux solely by the current generated in the thermo-couple 32 itself, and thus in most instances the relay device 34 may be omitted and the output of the thermo-couple 32 connected directly to the energizing coil 31.

As the temperature of the condensing region 15 rises, the thermo-couple 32 will generate an increasing current which will therefore increase the current in the coil 31, and likewise the transverse magnetic flux impressed upon the tube by the transverse pole pieces 30. This increase in

transverse magnetic flux will compensate for the decreased ability of the control electrode 4 to hold off positive voltages applied to the anode 3, and thus a predetermined value of voltage impressed upon the control electrode 4 will be sufficient to prevent a discharge from being initiated for a predetermined value of positive voltage impressed upon the anode 3, irrespective of the temperature or vapor pressure conditions within the envelope 1.

Instead of the thermo-couple 32 being held against the outside of the envelope 1, it is possible to place it within the envelope 1 so as to be directly responsive to the temperature conditions in said envelope. Likewise the thermo-couple 32 could be placed in the region surrounding the envelope 1 so as to be responsive to the temperature of the air surrounding said envelope. This is particularly true in the case where the tube is placed in an enclosure wherein the vapor pressure within the envelope will vary substantially in accordance with the pressure of said surrounding air. Therefore, when I use the term "ambient temperature" in the specification and claims, I use this term in a generic sense to cover any of the foregoing temperature conditions.

As set forth in my copending application, Serial No. 612,235, filed May 19, 1932, for an improvement in Electrical gaseous discharge devices, a transverse magnetic field impressed upon such a tube as I have described above may also be used to control the initiation of a discharge between the cathode and the anode. Thus in the drawing, the device 34 might represent a source of control current impressed upon the coil 31, and the device 27 might represent a source of relatively fixed bias on the electrode 4. Under these conditions, when a positive voltage is impressed upon the anode 3, a discharge will not be initiated between the cathode and the anode until the transverse magnetic flux falls to a predetermined minimum value. In this way the coil 31 would control the current flowing through the load device 22 substantially as described in connection with the control exerted by the electrode 4. However, under these conditions, likewise variations in temperature or vapor pressure within the envelope will produce variations in the control characteristics of the magnetic field. This variation likewise may be compensated for by impressing an increasingly negative voltage upon the electrode 4. For this purpose the switch 33a may be used to connected the output of the thermo-couple 32 to a pair of leads 36, which extend to the grid control device 27. Under these conditions the grid control device 27 would be constructed as an amplifier so that as the output from the thermo-couple 32 increased, the voltage upon the electrode 4 would become increasingly negative. In this way the tendency for the control effect of the magnetic field to vary would be counteracted by the increasingly negative bias on the control electrode 4, and a predetermined value of magnetic field would be enabled to prevent a discharge under a predetermined value of positive anode voltage, irrespective of changes in vapor pressure or temperature within the envelope.

Instead of compensating for variation in the magnetic field control by means of a voltage on the electrode 4, compensation could be accomplished by means of impressing a varying magnetic bias on the core 28. Thus, for example, the device 34 could be constructed to supply a bias value of direct current to the coil 31 upon

which an alternating control current could be superimposed. As the output of the thermo-couple 32 would increase, the device 34 would be arranged so as to increase the value of the bias direct current. This increase in bias current would likewise increase the direct component of flux, and would thus compensate for the variation in the control characteristics of the magnetic field. Instead of creating a bias flux by means of the single coil 31, an additional coil supplied with current, either directly from the thermo-couple 32 or through an intermediate relay device, could be provided on the core 29.

As pointed out above, a wide variety of arrangements are contemplated as being included within the scope of my invention. It will be apparent that other equivalents, both of tube structure and of circuit arrangement, will readily suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention.

What is claimed is:

1. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, means for controlling the initiation of a discharge between said cathode and anode in response to a controlling factor impressed on said means, an additional control means for controlling the initiation of a discharge between said cathode and anode in response to the energization thereof, and means responsive to the ambient temperature of said envelope for varying the energization of said additional control means.

2. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field in the discharge path between said cathode and anode and adjacent said electrostatic means, and means responsive to the ambient temperature of said envelope for varying said magnetic field.

3. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field in the discharge path between said cathode and anode and adjacent said electrostatic means, and means responsive to the temperature of said envelope for varying said magnetic field.

4. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field in the discharge path between said cathode and anode and adjacent said electrostatic means, and means responsive to the ambient temperature of said envelope for varying said magnetic field.

5. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable vapor, electrostatic means for controlling the initiation of a discharge between said cathode and anode in

response to the electrostatic potential impressed on said means, means for creating a magnetic field in the discharge path between said cathode and anode and adjacent said electrostatic means, and means varying as the pressure of the vapor within said envelope varies for varying said magnetic field.

6. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and mercury vapor, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field in the discharge path between said cathode and anode and adjacent said electrostatic means, and means varying as the pressure of the vapor within said envelope varies for varying said magnetic field.

7. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field intercepting the path of said discharge between said cathode and anode and adjacent said electrostatic means, and means responsive to the ambient temperature of said envelope for varying said magnetic field.

8. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, a control electrode surrounding the discharge path between said cathode and anode for controlling the initiation of a discharge between said cathode and anode, means for varying the electrostatic potential of said control electrode for controlling said discharge, means for creating a magnetic field intercepting the path of said discharge between said cathode and anode and adjacent said control electrode, and means responsive to the ambient temperature of said envelope for varying said magnetic field.

9. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field in the discharge path between said cathode and anode for controlling the initiation of a discharge between said cathode and anode in response to the energization of said means, and means responsive to the ambient temperature of said envelope for varying the energization of one of said control means.

10. In combination, an electrical space discharge tube comprising an envelope containing a cathode, an anode, and an ionizable medium, electrostatic means for controlling the initiation of a discharge between said cathode and anode in response to the electrostatic potential impressed on said means, means for creating a magnetic field transverse to the discharge path between said cathode and anode for controlling the initiation of a discharge between said cathode and anode in response to the energization of said means, and means responsive to the ambient temperature of said envelope for superimposing a biasing magnetic field upon said first-named field.