Oct. 6, 1942. C. G. SMITH 2,297,721

ELECTRICAL GASEOUS DISCHARGE CONTROL DEVICE

Filed July 30, 1940

Fig. 1.

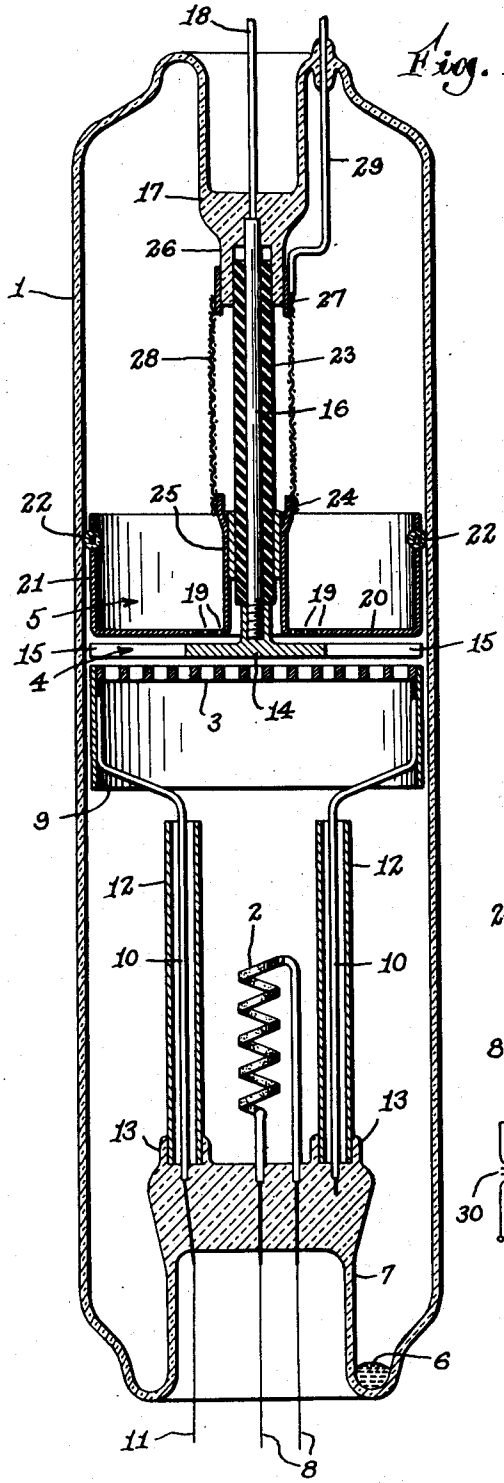


Fig. 2.

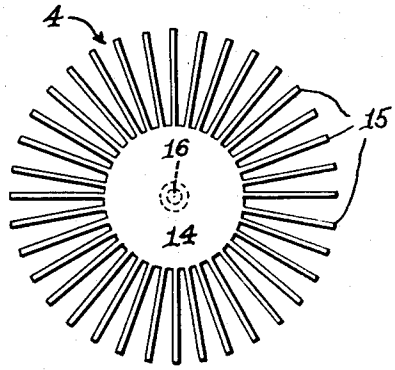
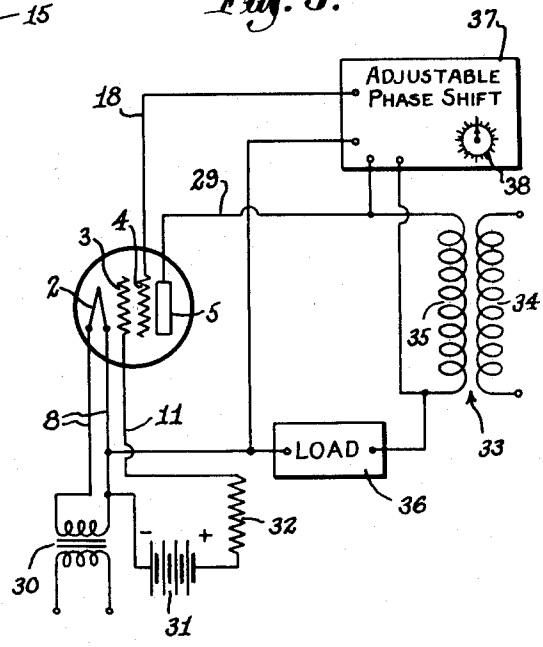


Fig. 3.



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ELECTRICAL GASEOUS DISCHARGE CONTROL DEVICE

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4 Claims. (Cl. 250—27.5)

This invention relates to an electrical gaseous discharge control device, and more particularly to such a device in which the control is effected by an electrostatic grid member.

An object of this invention is to produce such a device which is capable of handling currents of higher frequencies than have heretofore been practical.

Another object is to produce such a device in which the operation at lower frequencies is improved.

A further object is to restrict the degree of extension of ionization and to decrease the de-ionization time in such a device.

A still further object is to accomplish the foregoing and other objects by shielding the control grid by means of insulatingly short paths.

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:

Fig. 1 is a longitudinal cross-section of an embodiment of my novel device;

Fig. 2 is a bottom view of the control grid; and

Fig. 3 is a diagrammatic representation of one type of circuit in which the tube shown in Fig. 1 may be utilized.

The tube illustrated is of the grid-controlled gaseous discharge type, and consists of a sealed envelope 1 containing a cathode 2, an auxiliary grid 3, an electrostatic control grid 4, and an anode 5. The cathode 2 is preferably of the thermionic type, and may consist of a filament coated with electron-emitting materials, such as the alkaline earth oxides. The tube is filled with an ionizable gas, which may be one of the inert gases, or a vapor, such as mercury vapor, supplied from a drop of mercury 6. The envelope 1 is provided with two reentrant stems 7 and 17 at opposite ends thereof in order to support the various electrodes enumerated. The cathode 2 is supported by being sealed in the upper end of the stem 7, and is provided with a pair of lead-in conductors 8 extending through said stem.

The auxiliary grid 3 is provided for the purpose of separating the discharge region adjacent the cathode from the discharge region adjacent the other two electrodes, and is provided with perforations throughout its surface so as to permit the discharge to pass from the cathode to the other electrodes only through said perforations. In order to insure this operation, the auxiliary grid 3 is provided with a depending sleeve 9 around its outer edge. The sleeve 9 is spaced sufficiently close to the interior wall of the envelope 1 so that a discharge cannot pass through the space. Under these conditions, substantially none of the electrons will pass through said space, and substantially all of the electrons will pass through the perforations in the auxiliary grid 3. The auxiliary grid 3 is supported by a pair of standards 10 sealed in the stem 7 and welded in the upper ends to the sleeve 9. A lead-in conductor 11 sealed through the stem 7 is connected to one of the standards 10. It is also desirable to shield the cathode 2 from the effects of the grid standards 10, and for this purpose, each of said standards is shielded by a metal shield 12 supported in a glass sleeve 13 formed on the stem 7.

The control grid 4 is formed with an imperforate central portion 14 from which radiate a plurality of slats 15. The slats 15 are of substantial thickness and are sufficiently numerous to provide a relatively large surface at which rapid de-ionization of the gas between the auxiliary grid 3 and the anode 5 can take place. The spacing between the anode 5, the control grid 4, and the auxiliary grid 3, should be relatively close so as to reduce the total volume of ionized gas in which the control grid is located and preferably this spacing should be insulatingly short. Also, preferably the ends of the slats 15 extend to within an insulatingly short distance from the interior walls of the envelope 1. The control grid 4 is mounted on the outer end of a support rod 16, sealed in the upper stem 17 and provided with a lead-in conductor.

The anode 5 is in the shape of an annular cup. This cup is preferably provided at its central portion with a plurality of perforations 19 which permit the solid portion 14 of the grid 4 to radiate heat without excessive absorption thereof by the anode. For the same reason, the auxiliary grid 3 is also perforate adjacent the solid portion 14. Surrounding the centrally perforated portion of the anode 5 is an imperforate annular portion 20 at the outer edge of which is provided a sleeve 21, likewise spaced by an insulatingly short path from the interior walls of the envelope 1. By this arrangement, substantially all of the electrons which pass through the control grid 4 are captured by the anode 5, and substantially none of these electrons can pass beyond the anode 5 either through perforations 19 or around the sleeve 21.

The sleeve 21 is spaced from the walls of the envelope 1 by bumper insulators 22 which serve

to steady the structure mounted on the upper stem 17. The support rod 16 is surrounded by an insulating sleeve 23 of suitable insulating material such as lava, the upper end of which is retained in a glass sleeve 26 formed on the stem 17. A sleeve 24 is clamped around the lower end of the sleeve 23 and has welded thereto a central sleeve 25 formed as part of the anode 5. In this way, the anode is supported by the support rod 16. Clamped around the outside of the glass sleeve 26 is a metal ring 27. Surrounding the insulating sleeve 23 and welded to the ring 27, and the sleeve 25, is a screen 28 preferably made of mesh or otherwise perforated. The spacing between the sleeve 23 and the screen 28 is also an insulatingly short path so that high frequency discharges between the screen 28 and the surface of the insulating sleeve 23 are effectively prevented. In order to provide an external electrical connection to the anode 5, a lead-in 9 is welded to the ring 27 and sealed through the upper wall of the envelope 1.

The tube described above can be connected in any suitable circuit so as to control currents supplied thereto. Since it is particularly adapted to control high frequency currents, it may be connected in the circuit as illustrated in Fig. 3. In this circuit, the cathode 2 is supplied with heating current from a heating transformer 30. A source of ionizing potential, preferably a direct current source such as a battery 31, is connected between the cathode 2 and the auxiliary grid 3 through a current limiting resistor 32. The current to be controlled may be applied to the tube through a transformer 33 having a primary winding 34 connected to a source of alternating current which conveniently may be a high frequency source. The transformer 33 also has a secondary winding 35, one end of which is connected to the lead-in conductor 29 and the other end of which is connected through a load 36 to one of the lead-ins 8. Some suitable control voltage is applied to the control grid 4. This control voltage may be supplied from an adjustable phase shift device 37 energized from the secondary winding 35, and having its output connected between the auxiliary grid 3 and the cathode 2.

When the system as described above is energized, the cathode 2 is heated to temperature of thermionic emission, and an ionizing discharge passes between the cathode 2 and the auxiliary grid 3. This ionization may be relatively intense and thus maintains a body of relatively highly ionized gas in relatively close proximity to the controlled discharge space in which the control grid is located. This ionization is prevented from extension beyond the auxiliary grid 3 until a discharge is initiated to the anode 5. When the anode 5 becomes positive with respect to the auxiliary grid 3, a discharge will pass thereto provided the potential of the control grid 4 is of the proper value, depending upon the design of the tube and the value of the anode voltage. The voltage on the grid at which discharge starts may be either slightly negative, zero, or slightly positive. However, if the grid 4 is sufficiently negative in any case, a discharge cannot be initiated to the anode 5. The point in the alternating current cycle at which the control grid 4 permits the discharge to be initiated is determined, in the arrangement illustrated, by the phase of the voltage supplied to the control grid from the phase shift device 37. This phase may be selected by a calibrated control member 38 on the phase shift device 37. By delaying the phase, the anode starts to conduct later in the cycle, and thus the current to the load 36 is decreased. If the phase is advanced, the anode 5 starts to conduct earlier and the current to the load is increased.

By maintaining a body of ionized gas closely adjacent to the control grid 4 and the anode 5, there are no long paths along which ionization must be propagated in order to start a discharge during each cycle, and therefore, such a discharge can be initiated in a very short space of time. When the anode 5 becomes negative the discharge thereto ceases and the residual ionization in the space between the anode 5 and the auxiliary grid 3 is quickly cleaned up by the relatively extensive surfaces provided by the control grid 4 and the adjacent members. The restriction of the total volume of gas which must be thus de-ionized as described above facilitates and accelerates such de-ionization. Due to the arrangement as described, upon de-ionization of the space between the anode 5 and the auxiliary grid 3, said auxiliary grid prevents the extension of ionization beyond it to a sufficient degree to enable the control grid 4 to restrain the initiation of a discharge to the anode 5 during the succeeding cycle until the time as determined by the voltage on the control grid 4.

Due to the above arrangement, the tube can control currents of higher frequencies than have heretofore been possible. Furthermore, the tube is capable of handling large amounts of power. If during such operation, the electrodes 3, 4, or 5, become highly heated, such heat can readily be radiated from these structures so as to maintain the temperature within reasonable limits.

Of course, it is to be understood that this invention is not limited to the particular details as described above, as many equivalents will 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 the invention within the art.

What is claimed is:

1. In a gaseous discharge structure containing an ionizable gas and having a cathode and an anode between which an ionic discharge is adapted to occur, an auxiliary electrode having openings therein for the passage of the discharge therethrough, said electrode being interposed between the cathode and anode in the path of the discharge and having its effective surfaces spaced a distance of the order of the mean free path of the electrons in said discharge or less from the anode, said electrode cooperating with the discharge structure to substantially isolate a limited region between it and the anode from a larger region between said electrode and the cathode, the openings within said electrode being so large and the gas pressure so high that cumulative intense ionization occurs within the limited region during a discharge from the cathode to the anode, a deionizing control electrode arranged between the anode and auxiliary electrode within the limited region, said electrode being provided with a relatively large surface for rapid deionization of the ions within the limited region and being arranged for the passage of the discharge therethrough, and means restricting the discharge to a path through the auxiliary electrode and the deionizing control electrode.

2. In a gaseous discharge structure containing an ionizable gas and having a cathode and an anode between which an ionic discharge is adapted to occur, an auxiliary electrode having open-

ings therein for the passage of the discharge therethrough, said electrode being interposed between the cathode and anode in the path of the discharge and having its effective surfaces spaced a distance of the order of the mean free path of the electrons in said discharge or less from the anode, said electrode cooperating with the discharge structure to substantially isolate a limited region between it and the anode from a larger region between said electrode and the cathode, the openings within said electrode being so large and the gaseous discharge structure so arranged and constructed that cumulative intense ionization occurs within the limited region during a discharge from the cathode to the anode, and a deionizing control electrode arranged between the anode and auxiliary electrode within the limited region, said electrode being provided with a relatively large surface for rapid deionization of the ions within the limited region and being arranged for the passage of the discharge therethrough.

3. In a gaseous discharge structure containing an ionizable gas and having a cathode and an anode between which an ionic discharge is adapted to occur, an auxiliary electrode having openings therein for the passage of the discharge therethrough, said electrode being interposed between the cathode and anode in the path of the discharge and having its effective surfaces spaced a distance of the order of the mean free path of the electrons in said discharge or less from the anode, said electrode cooperating with the discharge structure to substantially isolate a limited region between it and the anode from a larger region between said electrode and the cathode, the openings within said electrode being so large and the gas pressure so high that cumulative intense ionization occurs within the limited region during a discharge from the cathode to the anode, and a deionizing control electrode arranged between the anode and auxiliary electrode within the limited region, said electrode being provided with a relatively large surface for rapid deionization of the ions within the limited region and being arranged for the passage of the discharge therethrough.

4. In the method of controlling an electrical discharge between an anode and a cathode the steps comprising isolating a limited portion of the region throughout which intense cumulative ionization occurs and deionizing said portion immediately upon termination of the discharge to the anode.

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