

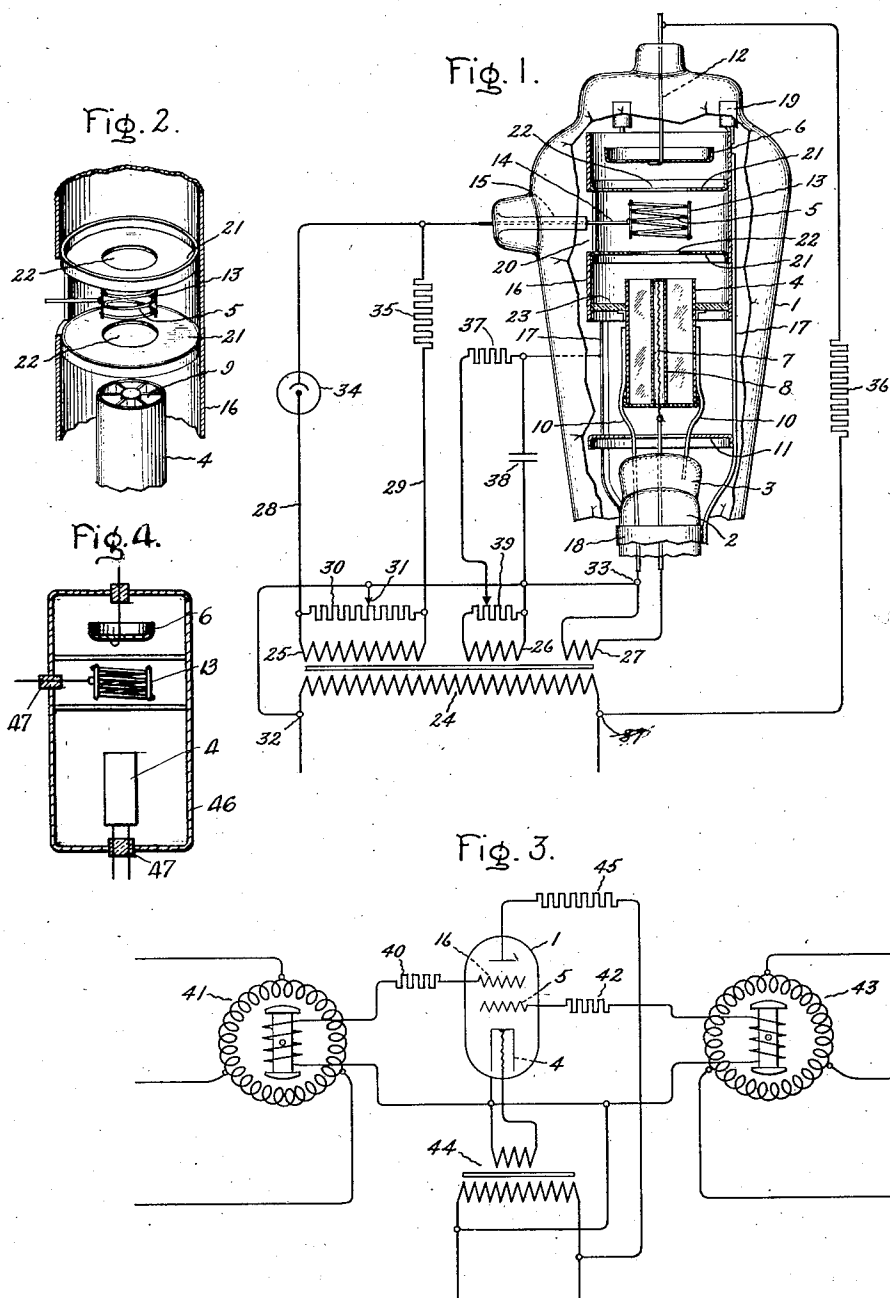
June 16, 1936.

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2,044,618

ELECTROSTATICALLY CONTROLLED ARC DISCHARGE DEVICE

Filed Dec. 29, 1933



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UNITED STATES PATENT OFFICE

2,044,618

ELECTROSTATICALLY CONTROLLED ARC
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Application December 29, 1933, Serial No. 704,503

24 Claims. (Cl. 250—27.5)

The present invention relates to thermionic discharge devices containing an ionizable medium and provided with cooperating electrodes including an electrostatic control member or grid for initiating an arc-like discharge. The invention is directed more especially to a means for shielding the control element, physically, thermally and electrostatically from the anode and cathode.

Devices of this general character are described in articles entitled "Hot cathode thyratrons" by A. W. Hull in the General Electric Review, vol. 32, No. 2, April 1929, pages 213 to 223, and vol. 32, No. 7, July 1929, pages 390 to 399. These tubes are characterized by a large power output which is reliably controllable, at least under proper conditions, by an exceedingly small amount of grid energy of the order of a fraction of a micro-watt. In addition to the cooperating electrodes, the devices contain an ionizable medium, for example, mercury vapor or argon at a pressure sufficiently high to support an arc-like discharge at the impressed voltage. The current which flows under these conditions has a flat or slightly negative volt-ampere characteristic and takes on some of the properties of an arc.

As stated in the articles referred to, the starting of the arc-like discharge or glow may be controlled by the grid, in other words, the grid may restrain the arc from starting, and after starting, the current flow preferably is stopped by removing the positive anode voltage. This is conveniently accomplished by applying to the cathode-anode circuit an alternating current voltage which enables the grid to regain control of the starting of the arc at the end of each positive half-cycle of the anode voltage. The control grid thus determines the average current flowing through the tube.

For this purpose, the grid is mounted intermediate the cathode and anode in such a position as to provide the necessary electrostatic field. The grid in the prior tubes has usually been a member of relatively large size, placed directly in the arc stream in order to obtain the maximum control or arc-restraining effect. It has been found that the grid, on account of its size and position, not only absorbs considerable quantities of heat radiated by the arc, by the cathode and by the anode, and furthermore, constitutes a depository for the active material sputtered from the cathode, but in addition, is deleteriously affected by capacity currents originating at the cathode or anode. In order to operate properly, it is apparent that the grid must not be permitted to heat up to a temperature at which any substantial electron emission will occur, particularly when there is an accumulated coating of active material thereon. Such coating may give rise, and probably does, to electron emission which offsets or otherwise neutralizes the control effect

of the instantaneous charges on the grid and to that extent, prevents the grid from exercising its optimum control. As for the capacity between the grid and anode or cathode, it is apparent that even though the interelectrode capacity is relatively small, the electrostatic induction effects may still be so large as to preclude the proper functioning of the grid on account of the large and sudden changes in the conduction of the tube and associated tubes, also the high frequencies developed at the electrodes during these changes. When a tube in a system containing a plurality of tubes, is triggered or fired by the grid, the plate voltage at the instant of breakdown drops almost instantly from a comparatively high value to about 10 or 20 volts, depending upon the ionization voltage of the gas or vapor used in the tube. This sudden change in voltage often produces a similarly sudden change in voltage across one or more of the remaining tubes of the system, which may cause premature firing or other incorrect operation of such remaining tubes due to electrostatic induction between the grid and the plate electrodes. The extent of surface presented by the grid to the remaining electrodes must also be considered in dealing with electrostatic induction under these conditions because the grids of the prior art are necessarily subject to intense electrostatic effects on account of their relatively large size.

It will be understood that in order to obtain constant average current, or in case a variable current is desired, in order to obtain a current which varies in a predetermined manner, the grid must trigger the tube at predetermined positions in each positive half-cycle of the anode voltage. This obviously is impossible if there is appreciable electrical interaction between the grid and anode, or if there is any other deleterious electrical or thermal condition surrounding the grid, and particularly when the voltage changes on the anode present steep wave fronts due to the sudden voltage changes in a system containing glow or arc discharge devices.

An object of the present invention is to provide an improved tube of the electrostatically controlled arc or glow discharge type in which the control member is shielded from the anode and cathode so that it may perform its electrostatic control function without interference, either thermal or electrostatic, from any of the remaining electrodes in the tube. In view of the improved controlling effect exercised by the grid in applicant's improved tube as will be described hereinafter, it is feasible to connect such a tube to a high impedance circuit and the grid will still function positively to regulate the triggering of the tube notwithstanding the heat radiated by the arc, cathode or anode, or the effects of large and sudden changes of voltage in the anode cir-

cuit. In brief, my invention contemplates the use of an improved grid structure and more particularly, an additional grid electrode which has suitable configuration and is properly biased and positioned to provide the necessary shielding effects.

For a better understanding of the invention, reference should be had to the following specification and accompanying drawing in which Fig. 1 shows an elevational view of a tube, partly broken away, and improved in accordance with the present invention and connected in a typical circuit; Fig. 2 is a perspective view of a portion of the grid structure, while Fig. 3 is a circuit diagram exemplifying an alternative method of utilizing the improved tube. Fig. 4 is a longitudinal view partly in section of a modified form of the improved tube.

In Fig. 1, numeral 1 designates the envelope of a tube which is shown as being broken away at the bottom but which actually terminates in the reentrant stem 2 provided with a press 3. The envelope contains a plurality of cooperating electrodes including a thermionic cathode 4, a control element or grid 5 and an anode 6. The cathode is of the well-known indirectly heated type and includes a heater 7 contained within a casing 8 which is provided with radially extending vanes 9. A metal cylinder surrounds these vanes and is secured thereto to form a series of recesses which are coated with electronically active material such as alkaline earth oxide.

The cathode is supported from the stem by means of rigid wires 10, a pair of which may conveniently serve as leading-in conductors for the heater and cathode respectively. A heat shield 11, preferably formed as an inverted dish-shaped member of metal, may be secured to one of these conductors to protect the press 3 from heat radiated by the cathode.

The anode 6 may also take the form of an inverted dish-shaped metal member, preferably carbonized or otherwise coated with carbon, and secured to the end of the envelope opposite from the cathode end by a rigid leading-in conductor 12. The control or grid member 5 consists of a small metal helix or a plurality of metal rings of relatively small gage wire, and the turns of which are secured together as a more or less unitary structure by a pair of longitudinally extending rigid wires 13 which extend along the length of the grid and are welded thereto at each convolution. The grid member is of a relatively small diameter, of a size to surround practically the entire arc stream flowing between the cathode and anode so as effectively to control the arc. The control element is mounted between the cathode and anode, by a rigid leading-in conductor 14 which extends transversely of the envelope and is sealed in a glass rod 15.

The envelope also contains an ionizable medium which may consist of an inert gas, such as argon, at a pressure from 1 to 500 microns, or vapor such as caesium, or a globule of mercury.

In accordance with the present invention, an additional element or electrode is mounted in the tube for purposes as will be described presently. This member may take the form of a relatively long cylinder 16 of metal or other conducting material extending between the cathode and anode, well beyond the active surfaces of the latter. The cylinder is of substantially larger diameter than the cathode and anode, and is supported at one end by a plurality of equidistantly spaced

rods 17 which are secured to a metal band 18 surrounding the stem 2. At the other end, the cylinder carries several insulators 19 which may constitute small cylindrical members of alumina (Al_2O_3) which bear against the interior surface of a portion of the envelope of reduced diameter.

The cylinder is provided at its approximate center with an opening 20, preferably of rectangular shape, through which the conductor 14 for the control grid passes. The cylinder is partitioned off by a pair of spaced plates or baffles 21 of metal or other conducting material, such as carbon, thereby forming a central or middle compartment within which the control grid 5 preferably is centrally mounted. These plates have openings 22 therein, preferably of the same configuration as the grid 5, which in the case illustrated is circular. While these plates are necessarily electrically connected together on account of being secured directly to the cylinder, it will be understood that, if desired, the plates may be insulated from the cylinder and electrically separated for the application of different potentials thereto as will be pointed out hereinafter. The diameter of these openings is somewhat smaller than the diameter of the grid so that it is impossible for the grid "to see" either the cathode or anode. The bottom of the cylinder is closed by an insulating member 23 which fits snugly about the cathode outer casing.

For energizing and controlling the tube, a typical alternating current circuit is shown which consists of a transformer primary 24 provided with three secondaries 25, 26 and 27 respectively. One of the end windings 27 may be used to energize the heater 7 while the other end winding 25 is connected through leads 28, 29 to the control electrode 5. A potentiometer 30 may be connected across the secondary 25 and a connection made from a sliding contact 31 on the potentiometer to one side 32 of the primary 24, and also to the cathode at the point 33.

The lead 28 may include a photo-electric tube 34 or other controlling device, while the lead 29 includes a high resistance 35 which may constitute part of a bridge circuit, as shown. The anode 6 is connected through a load 36, generically indicated as a resistance, to the end of the primary 24 opposite that to which the cathode 4 is connected.

The improved shielding electrode 16 is connected to the intermediate transformer secondary 26 through a circuit which is exemplified as including a resistance 37, a condenser 38 and a potentiometer 39 connected across the winding.

A tube of the type described serves to pass an arc-like or glow discharge between the cathode and anode during operation which has a flat or slightly negative volt-ampere characteristic. The arc or glow discharge produces a considerable quantity of heat within itself, also at the electrodes, which in addition to actually heating the grid by radiation, may cause severe sputtering at the oxide coated cathode, which, in turn, causes the electronically active material to volatilize or otherwise to deposit itself on any unshielded surface within reach, which may be the grid. Such a condition, of course, is undesirable. Moreover, when a tube of this character is operated in the typical circuit shown and is not provided with the shielding electrode 16 and is immediately associated circuit, the control member 5 is not only subject to the deleterious heating and sputtering effects referred to but also to interelectrode capacity effects arising from the cathode or anode.

It will be understood that the cathode as well as the anode presents large flat surfaces to the grid which may offer a strong "condenser" effect. The voltages of the charges on the cathode and anode of a given tube are constantly changing not only due to the alternating current voltage applied thereto but also due to the sudden drops in voltage produced across associated tubes of the system, which may give rise to complex voltage waves of extremely high frequencies. Moreover, due to faulty or improper operation of the associated tubes, for example, on account of low cathode emission or excessively low vapor pressure, other transient voltages may be generated within the system and impressed upon the tube in question. Consequently, even though the inter-electrode capacities of the given tube are relatively small, the electrostatic induction effects may still be large.

The combined effects of the thermal and electrostatic reactions on prior grids are often such that the control element does not respond accurately to the control or signal impulses applied thereto. Under these conditions, the use of the tube coupled directly to a source of weak impulses such as an energized photo-electric device is entirely out of the question, even though the grid circuit is of the so-called "stiff" type. These thermal and electrostatic effects also normally prevent or preclude the grid from firing or triggering the tube at the same or other predetermined points in the recurring positive half-cycles of the anode voltage unless abnormal and inefficiently large charges be applied to the grid. The necessity for such large controlling charges obviously detracts from the usefulness of the tube, as a considerable part of its application consists in being readily and accurately controllable by weak impulses.

It has been found that by the use of the improved shielding member 16, many of the conditions which have heretofore deleteriously affected the grid are eliminated or at least substantially reduced. In the first place, by positioning the control member within the middle compartment of the shielding electrode where there is a metal partition between the control element and anode, also between the control element and the cathode, the control member is protected from heat radiated by the anode and cathode. Thus the control element is substantially isolated from the thermal standpoint and this condition in turn, leads to the advantage that the grid is maintained reasonably cool and does not tend to emit electrons.

The smallness of the circular openings 22 in the plates or partitions 21, also the proximity of the surrounding metal wall of the cylinder tend to constrict the arc into a well-defined circular column between the cathode and the anode and this constriction permits the grid electrode, which is also of circular configuration and through which the entire column passes, to exercise its optimum control without being subject greatly to the heat generated within the arc itself. Moreover, due to the small size of arc, the control grid need only be of a correspondingly small size. In fact, in the construction shown, it is necessary that the grid should be only so large as to barely surround the small arc stream. The grid may be made smaller yet by placing the member in such a position as to suitably control the arc without surrounding the same, for example, the electrode may take a flat configuration and be positioned immediately adjacent to one edge of the

opening 22. The smallness of the grid required to control the arc is directly attributable to the restricted size of the arc column which in turn, is brought about by the improved shielding member 16 and the restricted openings therein. The grid may be made smaller than the prior grids employed in tubes of this character and this reduction in size not only tends to minimize the grid current flowing at the time the arc is initiated as well as during the time the discharge flows, but in addition, considerably lowers the electrostatic capacity effects between the grid and the remaining electrodes.

As stated hereinbefore, the grid 5 is of slightly larger size than the openings 22, and this arrangement offers the advantages of interposing between the grid and the cathode a substantial portion of the plate 21 which tends to collect active material sputtered from the cathode and which normally would have condensed or otherwise collected on the grid. Thus the grid is kept free from material which may give rise to electron emission and destroy or reduce its control effect. Moreover, that portion of each partition 21 which is interposed either between the grid and the cathode or between the grid and the plate effectively serves as a barrier for intercepting the electrostatic lines of force which might pass between the electrodes and cause electrostatic induction. The cylindrical part of the shielding electrode 16 intercepts the remaining electrostatic lines which extend in curved paths from the electrodes so that all of the interelectrode capacity between the control electrode and the anode or cathode is substantially eliminated.

While I have shown a circuit which includes a resistance 37 and a condenser 38 for charging the shielding electrode 16, it will be understood that any other form of circuit by which the proper bias potentials, alternating or direct current, or combination of both, are applied to the shield may be used. The condenser serves the purpose of maintaining a fixed potential on the electrode with respect to the cathode, thereby enabling the electrode to perform its shielding function in a satisfactory manner. When the anode of the tube is energized by alternating current, it is found satisfactory under certain circumstances, to apply alternating current potential to the shielding member, and in this case, the desired potential conveniently may be taken from the same transformer as provides the anode voltage. By other types of circuits, the phase of the potential applied to this member may be adjusted to have any other desired phase relation. In some cases, it is desirable to charge the shielding member directly to cathode potential which conveniently may be done by connecting these elements together within the envelope by an equipotential conductor.

A tube of the type described and improved in accordance with the present invention, i. e. provided with the improved shielding electrode, has been found to operate directly from a photo-electric tube 34, in a manner which is superior to the operation of the tube had the shielding electrode been removed or otherwise not used. In the absence of the improved electrode, it has been found necessary, in some cases, in order to obtain reliable operation, to interpose an additional thermionic device, e. g. of the highly evacuated space charge limited type between the photo-electric tube and the arc or glow discharge device to serve as an intermediate relay.

Consequently, in the specific circuit illustrated, 75

the provision of the shielding electrode has in effect eliminated the necessity for the intermediate relay and to this extent, represents a distinct saving in apparatus. Moreover, when the tube is to be used in other typical circuits which may not include a photo-electric tube but which calls for the triggering or initiating of the arc or glow in the tube at predetermined points in the recurring positive half-cycles of the anode voltage, a tube which has been provided with the shielding electrode is found to give constant or other predetermined value or values of current output, which indicates that the grid exercises its control function entirely independently of the adverse electrical and thermal conditions present in the tube. Indeed, even in the case of high voltage transients appearing at the anode which frequently occur in systems containing arc or glow discharge devices, thus causing the anode voltage to change at a terrific rate, the grid element will still be found to exercise its control function entirely independently of the drastic changes in anode potential so long as the shield member remains at a fixed potential with respect to the cathode.

Fig. 3 shows another typical circuit in which the improved tube may be used to advantage. In this figure, the tube is designated by the reference character 1 and contains an indirectly heated cathode 4, a control element 5 and the improved shielding member 16. These electrodes may have substantially the same configuration and arrangement as the corresponding elements designated by similar reference characters in Fig. 1. The electrodes 5 and 16 constitute a double grid or dual control in which the electrostatic field of one grid may be modified by that of the other depending upon the potentials and polarities employed and their composite electrostatic effect arranged to control the initiation of the discharge in the device 1. The electrode 16 is shown as being connected through a current-limiting resistance 49 to the armature of a Selsyn motor 41 which offers a convenient method of shifting the phase of the voltage applied to the element 16. The grid 5 may likewise be connected through a current-limiting resistance 42 to a Selsyn motor 43 which is also adapted to shift the phase of the voltage applied to the grid 5. The heater of the cathode 4 is energized through the transformer 44. The alternating current voltage for the output circuit of the arc or glow discharge device 1 may be obtained directly from the current supply mains. The load for the device is generically indicated as a resistance 45.

The operation of the circuit shown in Fig. 3 will be readily understood. Phase-shifting devices are provided in the respective grid circuits for varying the phase of the potential applied to the respective grids and when the composite effect of these combined potentials reaches a predetermined value and polarity, depending upon the characteristics of the device, a glow or arc is initiated and current of large amount temporarily flows through the load 45. With the same setting of the Selsyn motors or other phase-shifting devices, the same average current will flow through each recurring half-cycle of the anode voltage. In view of the superior shielding effects provided by the electrode 16, the grid 5 performs its control function practically independently of the electrical and thermal conditions present in the tube. Furthermore, the grid 5, also the grid 16 exercise their arc-restraining

functions substantially independently of one another. The control exercised at the grid 5 is so critical and accurate that the power input at the control grid 5 may be of a minute character, even of the order of a few micro-watts, which obviously requires a phase-shifting device or Selsyn motor of only a small size. Thus, in the circuit illustrated, which represents only one of the many circuits to which my invention applies, there is a direct saving in the power, size and cost of apparatus necessary to provide a most accurate control of the arc or glow discharge by the control element, and this saving is directly attributable to the enhanced shielding effects, i. e. thermal and electrostatic, provided by the member 16.

While I have described a particular form of shielding member, the invention is applicable to constructions other than those illustrated herein. For example, in my application, Serial No. 17,765, patented concurrently herewith, and assigned to the General Electric Company, I have disclosed and claimed a concentric cylindrical electrode assembly in which the shielding means may consist of a pair of cylindrical members, which are positioned on each side of the control electrode and are provided with lateral openings for the passage of a discharge therethrough.

Furthermore, in the type of construction described instead of having the shielding electrode contained within a glass or metal envelope, the electrode itself may constitute the envelope 46, as shown in Fig. 4, in which case the anode 6, cathode 4 and the control member 13 would be insulatingly supported within the metal envelope by means of glass seals 47. The metal envelope can be evacuated in any suitable and well-known manner.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An electric discharge device comprising an envelope containing electrodes and a control element, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge between said electrodes at the impressed voltages, and means including a baffle member, shielding the entire control element from heat radiated by one of the cooperating electrodes, said member being electrically independent of the control element.

2. An electric discharge device comprising an envelope containing an anode, a cathode and a control element, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge between the cathode and anode at the impressed voltages, and means including baffles respectively between the control element and each of the anode and cathode for shielding the control element from heat radiated by the anode and cathode.

3. An electric discharge device comprising an envelope containing a plurality of electrodes including a cathode coated with electronically active material, an anode and a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, and means including a baffle member for shielding the entire control element from active material sputtered by the cathode.

4. An electric discharge device comprising an envelope containing a cathode coated with electronically active material, an anode and a con-

5 trol element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, and means including a baffle member for shielding the entire control element from the heat radiated by the cathode and from the active material sputtered by the cathode, and means including a member adapted to be electrically charged for shielding the entire control element from the electrostatic effects of the cathode and anode.

10 5. An electric discharge device comprising an envelope containing a cathode coated with electronically active material, an anode and a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support a discharge having a negative volt-ampere characteristic at the impressed voltages, and means for shielding the control element from the heat radiated by the cathode, also from active material sputtered by the cathode, said means including a partition member interposed between the control element and the cathode, and means for shielding the control element from the electrostatic field of the anode, said last-mentioned means including a partition member interposed between the control element and the anode.

20 6. An electron discharge device including the combination of a cathode coated with electronically active material, an anode, an interposed control electrode, and an ionizable medium having a pressure under operating conditions sufficient to support an arc-like discharge between the cathode and anode at the impressed voltages, a baffle of conducting material between the control member and the cathode for shielding said member from heat radiation and sputtering effects at the cathode, a baffle of conducting material between the control member and the anode for shielding said member from heat radiation and electrostatic effects at the anode, said baffles being electrically connected together.

30 7. An electron discharge device including the combination of a cathode coated with electronically active material, an anode, an interposed control member and an ionizable medium having a pressure under operating conditions sufficient to support an arc-like discharge between the cathode and anode at the impressed voltages, a baffle between the control member and cathode for shielding said member from heat radiation and sputtering effects at the cathode, a baffle between the control member and the anode for shielding said member from heat radiation and electrostatic effects at the anode, said baffles consisting of sheet metal members provided with openings to leave strips of metal, the width of each strip being greater than the width of the portions of the control member which are respectively adjacent to each of the strips.

40 8. An electron discharge device including the combination of a cathode coated with electronically active material, an anode, an interposed control member and an ionizable medium having a pressure under operating conditions sufficient to support an arc-like discharge between the cathode and anode at the impressed voltages, a baffle between the control member and cathode for shielding said member from heat radiation and sputtering effects at the cathode, a baffle between the control member and the anode for shielding said member from heat radiation and electrostatic effects at the anode, said baffles consisting of sheet metal members

provided with openings to leave strips of metal, said openings being of relatively small size compared to the size of the respective baffles in order to constrain the arc to a well-defined stream of relatively small cross-section under operating conditions, and a control member of correspondingly small size mounted adjacent each of said openings for controlling the localized arc stream.

9. An electric discharge device comprising an envelope containing a cathode, an anode and a control element, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode interposed between the cathode and anode and provided with transversely extending partitions spaced apart to form a compartment, said control element being mounted in said compartment.

10. An electric discharge device comprising an envelope containing a cathode, an anode, and a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode of substantially the same configuration as the cathode and anode and surrounding said cathode and anode, said hollow electrode being provided with transversely extending partitions spaced apart to form a compartment, said control element being mounted in said compartment.

11. An electric discharge device comprising an envelope containing a cathode, an anode, and a control element, an ionizable medium in said envelope having a pressure under operation conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode of substantially the same configuration as the cathode and anode and surrounding said cathode and anode, said hollow electrode being provided with transversely extending partitions spaced apart to form a compartment, said control element being mounted in said compartment, said partitions having openings of a configuration similar to that of the control element, in register with one another, and of smaller size than the control element, whereby the control element is shielded from the cathode and anode.

12. An electric discharge device comprising an envelope containing a plurality of electrodes including a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow cylindrical electrode surrounding the cathode and anode and provided with transversely extending partitions spaced apart to form a compartment, said control element being mounted in said compartment, said cylindrical electrode being also provided with a peripheral opening through which the conductor for the control element passes.

13. An electric discharge device comprising an envelope containing an indirectly heated cathode, an anode and a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, said cathode being of the indirectly heated type and provided with an outer casing, a hollow cylindrical electrode surrounding the cathode and anode and provided with transversely extending partitions spaced apart to form a compartment, said control element being mounted in said compartment

ment, said cylindrical electrode being also provided with a peripheral opening through which the conductor for the control element passes, and a ring of insulating material positioned between the outer casing of the cathode and the interior surface of the hollow electrode whereby the hollow electrode is closed at the cathode end and is open at the anode end.

14. An electric discharge device comprising an envelope terminating in a reentrant stem, a cathode, anode and control element, also an ionizable medium in said envelope, a hollow electrode interposed between the cathode and anode, said electrode being provided with transversely extending partitions spaced apart to form a compartment, said control element being arranged in said compartment, said cathode and hollow electrode being supported from said reentrant stem, and said anode being supported from the opposite end of the envelope.

15. An electric discharge device comprising an envelope containing a cathode, an anode, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode interposed between the cathode and anode and provided with a transversely extending partition, a restricted discharge opening in said partition for constraining the arc to a relatively small size, and a control member of correspondingly small size mounted adjacent said opening for controlling the localized arc stream.

16. An electric discharge device comprising an envelope containing a cathode, an anode and a control element, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode surrounding the cathode and anode, said electrode being provided with a transversely extending partition, a restricted discharge opening in said partition for constraining the arc to a relatively small size, and a grid of correspondingly small size mounted adjacent said opening and between the partition and anode for controlling the localized arc stream.

17. An electric discharge device comprising an envelope containing a cathode, an anode and a control element, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode surrounding the cathode and anode, said electrode being provided with a transversely extending partition, a restricted discharge opening in said partition for constraining the arc to a relatively small size, and a grid of correspondingly small size mounted adjacent the opening and between the partition and cathode for controlling the localized arc stream.

18. An electric discharge device comprising an envelope containing a cathode, an anode and a control element, and an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, a hollow electrode surrounding the cathode and anode and provided with transversely extending partitions spaced apart to form a compartment, a restricted discharge opening in each of said partitions for

constraining the arc to a relatively small size, and a grid having substantially the same configuration as that of the openings and of correspondingly small size mounted in said compartment for controlling the localized arc stream.

19. An electric discharge device comprising an envelope constituted at least in part of metal and containing a plurality of electrodes including a cathode coated with electronically active material, an anode and a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, and means including a baffle member for shielding the entire control element from the active material sputtered by the cathode, said means being constituted, at least in part, of the metal portion of the envelope.

20. An electric discharge device comprising an envelope constituted at least in part of metal and containing a plurality of electrodes including a control element, an ionizable medium in said envelope having a pressure under operating conditions sufficient to support an arc-like discharge at the impressed voltages, and means including a member adapted to be charged to a different potential than the control element for shielding the control element from the electrostatic field of the remaining electrodes, said means being constituted, at least in part, of the metal portion of the envelope.

21. An electric discharge device comprising an envelope containing cooperating discharge electrodes, an ionizable medium in said envelope and shielded discharge controlling means between said cooperating electrodes, said means consisting of a unitary electrostatic control element and a baffle having at least portions thereof interposed between the entire control element and one of the cooperating discharge electrodes and being electrically independent of the control element.

22. An electric discharge device comprising an envelope containing an anode and a cathode, an ionizable medium in said envelope and discharge controlling means between said anode and cathode, said means consisting of a unitary electrostatic control element, and a baffle having at least a portion thereof interposed between the entire control element and the cathode and being electrically independent of the control element.

23. An electric discharge device comprising an envelope containing an anode, an ionizable medium in said envelope and discharge controlling means between said anode and cathode, said means consisting of a unitary electrostatic control element and a baffle having at least a portion thereof interposed between the entire control element and the anode and being electrically independent of the control element.

24. An electric discharge device comprising an envelope containing cooperating discharge electrodes, an ionizable medium in said envelope and shielded discharge controlling means between said cooperating electrodes, said means consisting of a unitary electrostatic control element and a conducting baffle having at least a portion thereof interposed between the entire control electrode and one of the cooperating discharge electrodes and being adapted to be charged to a different potential than the control element.

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