Feb. 25, 1947. E. J. LAWTON 2,416,661

DISPENSER TYPE CATHODE ELECTRIC DISCHARGE DEVICE

Filed May 28, 1943

Fig.1.

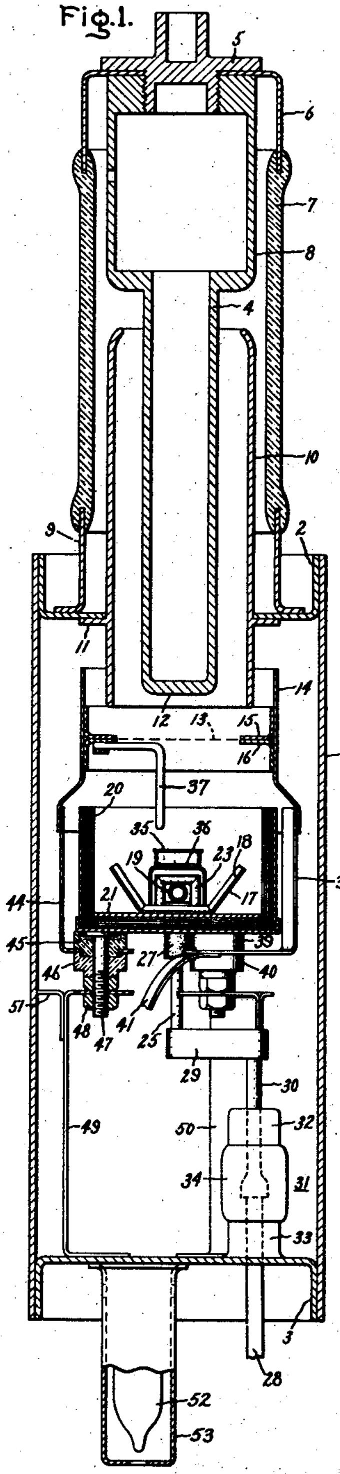


Fig.3.

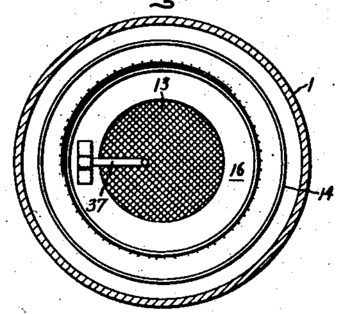


Fig.4.

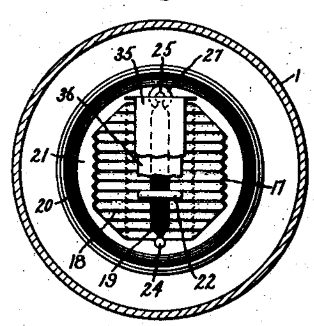
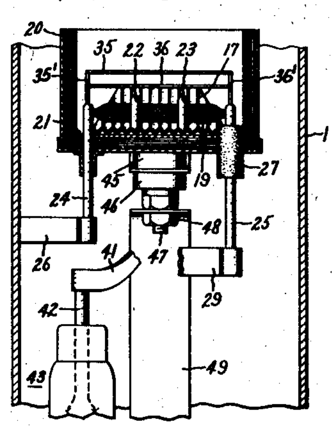


Fig.2.



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UNITED STATES PATENT OFFICE

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DISPENSER TYPE CATHODE ELECTRIC DISCHARGE DEVICE

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13 Claims. (Cl. 250—27.5)

1

My invention relates to electric discharge devices and more particularly to electric discharge devices of the type employing ionizable mediums such as gases or vapors.

It is an object of my invention to provide a new and improved electric discharge device.

It is another object of my invention to provide a new and improved cathode construction for an electric discharge device.

It is a further object of my invention to provide a new and improved electric discharge device of the type employing an ionizable medium such as a gas or a vapor.

It is a still further object of my invention to provide a new and improved electric discharge device which establishes current conduction between the anode and the cathode by virtue of an arc discharge within a short interval of time, such as a microsecond or less, and wherein the elements are arranged to permit a very rapid rate of rise of the anode-cathode current without unduly lengthening the deionization time of the device.

It is a still further object of my invention to provide a new and improved electric discharge device of the arc discharge type which is susceptible of transmitting between principal electrodes, such as the anode and cathode, current of relatively large value without affecting deleteriously the effective life of the cathode.

Briefly stated, in the illustrated embodiment of my invention I provide a new and improved construction for electric discharge devices of the type employing an ionizable medium, such as a gas or a vapor. The ionizable medium may comprise mercury at a suitable pressure preferably ranging from one or several microns to twenty-five microns of mercury for the following described range of voltages and operating frequency. A cathode construction is employed wherein a metallic member comprising a metal chosen from the class of metals such as tungsten and molybdenum is formed to have a concave surface facing the anode and which serves as the emissive part of the cathode structure. Within the concave region formed by the metallic member there is placed, preferably in a horizontal position, a dispenser element which may be described generally as being of a stocking-like nature defined by a plurality of interlaced or woven fine molybdenum wires and containing a eutectic mixture capable of dispensing an activating material which is deposited continuously during operation of the device upon the concave surface of the metallic member, thereby rendering it electron emissive to an extent sufficient to support the arc discharge. The configuration of the metallic member is such that it extends substantially beyond the dispenser element, in at least one and preferably two or more sides, towards the anode, thereby serving to reflect a substantial part of the radiant energy incident to the operating temperature of the dispenser element which is heated electrically by the transmission of electric current therethrough.

2

In order to minimize the flow of heat from the dispenser element in particular and the cathode in general, the cathode is provided with a cup-shaped heat shield surrounding the aforementioned metallic member and dispenser element and which extends an appreciable longitudinal distance towards the anode. As a further means for minimizing the heat flow from the dispenser element, I provide a plurality of spaced metallic members, which may be planar in form, above the dispenser element in a direction towards the anode.

To accelerate the initiation of the arc discharge between the anode and the cathode, in accordance with the dictates of the potential variations of a grid structure interposed between the anode and the cathode, I provide a starting member, which may be termed a grid control starting wire, preferably supported by and at the same potential as the grid and extending towards the cathode and the planar metallic members thereabove but in spaced relation with respect thereto. Upon suitable variation in the potential of the grid and the grid starting wire causing a relatively high electric field gradient to be established between the end of the grid starting wire and the upper planar member I have found that the ionization time or the time of initiation of the arc discharge between the anode and the cathode is substantially reduced and constitute a definite improvement over the arrangements provided heretofore in devices or systems where speed of cyclic operation is desired.

The structure which I provide is capable of operation at a high repetition rate; that is, the device is capable of establishing current flow between the anode and the cathode at rates equal to or greater than 600 amperes per microsecond, establishing conduction of anode-cathode current for a predetermined interval of time, and effecting interruption of the anode-cathode current within an overall interval of time equal to or less than one microsecond. Furthermore, the discharge device described hereinafter is capable of performing the above described operation at a rate of 400 or more times per second.

In view of the foregoing, it will be appreciated that electric discharge devices subjected to such strenuous cycles of operation ordinarily would impose an inordinate burden or duty cycle on cathode constructions of the conventional type. The cathode construction described hereinafter affords long cathode life, ability to establish the above described cyclic current variations, permits the use of relatively high anode voltages within the neighborhood of 20,000 to 40,000 volts or greater, and affords a relatively short deionization time commensurate with the above described cyclic operation. As a further matter, the discharge device affords minimization of electric field stresses due to the optimum spacing of the electrodes and of an electrostatic shield associated with the anode and the grid.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims. Fig. 1 is a cross-sectional longitudinal view of an electric discharge device built in accordance with my invention, and Fig. 2 is a partial cross-sectional view taken at a plane displaced 90 geometrical degrees with respect to that shown in Fig. 1. Fig. 3 is a cross-sectional view showing the grid structure and the grid starting wire, and Fig. 4 is a plan view, shown partly broken away, of the cathode construction including the dispenser element and the planar heat shields positioned thereabove.

Referring now to Fig. 1 of the accompanying drawing, I have there illustrated my invention as applied to an electric discharge device including a tubular metallic member 1 which defines a part of the enclosing structure or envelope for the elements of the device, and which is provided at its ends with flanged metallic end pieces 2 and 3 which are preferably welded or soldered to the inner surface of tubular member 1 near the ends thereof. The anode 4 is preferably of elongated nature as illustrated, being supported from the top of the enclosing and supporting structure by means of a threaded adaptor cap 5, a metallic end part 6 and a tubular vitreous insulator 7, all of which constitute part of the enclosure structure or envelope of the discharge device. The upper part 8 of the anode 4 may be of larger diameter than the lower part in order to establish the optimum distances between the anode and the enclosing structure, particularly the inner surface of the vitreous insulator 7. The anode may be constructed of any suitable metal; I have found that iron may be employed for this purpose. If desired, the exterior surface of the anode may be finished or ground as smooth as possible in order to minimize electric field gradients. The vitreous insulator 7 may be supported in turn by means of a metallic collar 9 which is sealed to the lower end of the insulator and which is also welded to the end piece 2.

In spaced relation between the restricted lower part of the anode and the inner surface of the enclosing envelope, I provide an appropriately spaced electrostatic shield 10 constructed of metal and having a tubular configuration provided with a flange 11 which serves as a support therefor. The flange 11 may be welded or soldered to the end piece 2 in the manner illustrated.

In spaced relation with the anode cooperating surface 12, I provide an electrostatic grid 13, preferably of a mesh type consisting of a plurality of wires defining spaces the areas of which and the aggregate effect thereof being determined by the requirements imposed by the arc ignition and the arc deionization times. In order to obtain the desired rate of rise of anode-cathode current in accordance with the grid potential, I have found that a relatively coarse grid structure should be employed. For example, one form of grid structure which I have found to operate successfully is one defining twelve substantially square openings per linear inch formed by 15 mil molybdenum wire.

The grid 13 is supported by a metallic grid supporting member 14 and which may be provided on the inner surface with a pair of adjoining flanged supporting members 15 and 16, the latter two members serving to hold the grid 13 in the desired spaced relation with respect to the anode, particularly the cooperating surface 12 thereof.

The cathode construction which I provide and which is described in detail hereinafter is an improvement of the structures disclosed and claimed in U. S. Letters Patents No. 2,201,731 and No. 2,246,176, granted May 21, 1940, and June 17, 1941, respectively, upon applications of Albert W. Hull, and which are assigned to the assignee of the present application. The cathode which I provide may be generally described as being of the dispenser type which comprises a stocking-like member including a eutectic mixture which continually produces or distils an activating material which is deposited on the cooperating surface of the cathode structure, thereby rendering it electron emissive, and which may be considered in conjunction with the dispenser surface as the active surface of the cathode. The evolution of the activating material proceeds continuously during intended operation of the discharge device, and is effected by the transmission of an appreciable value of current through the stocking or the dispenser element sufficient to raise the temperature thereof to a value which distils or dispenses the activating material.

Referring more particularly to the drawing, I provide an improvement which comprises a metallic member 17, preferably chosen from that class of metals consisting of tungsten and molybdenum, and which is arranged to have a form or configuration providing a concave surface 18 facing the anode of the discharge device. The member 17 may be corrugated as illustrated in Figs. 2 and 4 and may be generally described as having a pan or dish shape. I contemplate the provision of such a member which not only affords a relatively large projected area, viewed from the anode position, but which also has a sufficient longitudinal dimension along and beyond the dispenser element to be described presently and which effects the reflection of a substantial amount of the radiant energy due to the operating temperature of the dispenser element.

Within the concave region defined by member 17, I provide a dispenser element 19 shown in longitudinal and planar views in Figs. 2 and 4, respectively. The dispenser element 19 comprises a stocking-like fabric defined by closely woven molybdenum wires and is preferably horizontally disposed near the bottom of member 17. The eutectic mixture within the stocking fabric may comprise barium oxide and aluminum oxide in granular form which upon raising the temperature thereof to values within the vicinity of 1250° C. causes the dispensation of barium oxide from the stocking to the surrounding molybdenum member 17, rendering the latter electron emissive.

The metallic member 17 and the dispenser element 19 are surrounded by a heat shield 20 which may have a cup-shaped configuration as illustrated, and may comprise a plurality of laminations of relatively thin prick-punched metal. The heat shield, it will be noted, extends appreciably in a longitudinal direction beyond the aforedescribed cathode elements and may be provided with a metallic face plate 21.

The dispenser element 19 is supported by and maintained in insulated relation with the bottom surface of the metallic member 17 by means of refractory insulating supports 22 and 23, each of which may comprise a plurality of appropriately formed segments held together by means of threading, supporting and retaining wires (not shown).

Electric current for raising the temperature of the dispenser element 19 to the desired operating value may be furnished to this element by means of a pair of conductors 24 and 25, the former of which is electrically connected to the tubular member 1 through a strip conductor 26 and the latter of which is insulated from the cathode structure parts 17 and 20 by means of a tubular insulator 27, and which is in turn connected to an externally accessible terminal 28 through a strip conductor 29 and conductor 30. Conductor 30 is sealed to the enclosing envelope by means of a sealing structure 31 which may comprise a pair of metallic collars 32 and 33 and an intervening vitreous tube 34. The sealing structure 31 may employ metals, such as alloys of iron, nickel and cobalt or variations thereof.

In order to further minimize the flow of heat from the dispenser element 19, I provide means positioned above the dispenser element for reflecting the radiant energy incident to the operating temperature of the dispenser. This means may comprise a pair of spaced planar metallic members 35 and 36 positioned above the dispenser element 19 and which are supported from member 17 by means of metallic strips or rods 35′ and 36′.

The planar members 35 and 36, particularly the former, serve an additional purpose in the discharge device which I provide in that they offer a point or a plane with which an arc accelerating means, such as grid starting wire 37, cooperates to establish a relatively high electric field gradient in accordance with the dictates of the grid potential. The grid starting wire 37 is preferably electrically connected to the grid supporting structure, principally member 14 or member 16 as shown, and the potential thereof consequently varies in accordance with the potential of the grid. I have found that in one type of electric discharge device which operates successfully that the end of the grid starting wire 37 may extend towards the plane of member 35 to establish a distance of approximately one-quarter of an inch therebetween. The plan view of Fig. 3 shows the manner in which the grid starting wire 37 may be supported to the grid structure, principally the grid supporting member 16.

Electrical connection to the grid structure including the mesh grid 13 and the grid starting wire 37 may be accomplished by means of a metallic strip conductor 38 which is supported between a pair of insulating washers 39 and 40 fastened to the cathode structure, and which is ultimately connected to an externally accessible terminal through another conductor 41, and a lead-in conductor 42 (Fig. 2), the latter of which may be provided with a sealing structure 43 similar to the sealing structure 31 described hereinbefore.

The grid structure may be mechanically supported in the position illustrated by additional annularly spaced members such as strips of metal 44 which are welded at their upper extremities to the member 14 and are supported at their turned-in lower extremities by means of insulators 45 and 46 which are held in close spaced relationship, thereby securing the supporting members by means of a suitable mechanical expedient which may comprise a bolt 47 and nuts 48. The entire above described cathode structure, which in turn supports the grid structure, may be held in the desired axial or longitudinal positions by means of a plurality of circumferentially spaced mechanical supports only two of which, 49 and 50, are illustrated. These mechanical supports may consist of strips of metal such as iron or steel and which are welded to the inner surface of end piece 3. Desired radial or horizontal spacing may be obtained by attaching to each of the latter members a flanged strip 51 which engages the inner surface of tubular member 1, thereby accurately centering the entire structure particularly the cathode and grid elements.

A vitreous tubulation 52 may be employed for evacuation purposes and may be sealed to the end piece 3. Where an ionizable medium such as mercury is employed, the mercury to a certain extent tends to collect in this tubulation or appendix. The temperature of the mercury may be controlled by providing an open-ended hollow tube 53 which may be of metal surrounding the tubulation 52 and may also be affixed to end piece 3. A chimney effect may be obtained by the provision of a plurality of spaced openings near the top of tube 53 so that a chimney-like cooling action is obtained.

A cathode terminal for the above described discharge device may be obtained by connection to the tubular member 1 or the end piece 3 inasmuch as one terminal of the cathode, especially the dispenser element 19, is at the potential of the tubular member 1, being connected thereto through conductors 24 and 26.

In the above described type of operation comprising the transmission of a series of distinct pulses of current between the anode and cathode, an ordinary oxide coated cathode is subjected to inordinate operating burdens. The above described type of construction for the cathode affords a sufficiently long life for the cathode in particular, and the discharge device in general, even when subjected to this type of operation.

Furthermore, in the transmission of a pulse of current having a duration of one-tenth to two-tenths of a microsecond, the potential of the grid is caused to become positive temporarily, the the magnitude of the positive variations of grid potential rising to the order of 20 to 50 volts. As is well appreciated by those skilled in the art, if the potential of any part of the discharge device effectively cooperating in the arc discharge phenomenon rises above a particular value for the specific ionizing medium employed, the positive ions of the medium are accelerated towards the cathode structure thereby dislodging the activating material of the cathode and causing cathode sputtering, irregular operation and reduction in the effective life of the device. However, in the above described device employing the improved form of dispenser cathode in which the emitting surface offers a large projected area facing the anode and which is being continuously renewed by virtue of the dispensation of the activating material from the dispenser element 19 to surface 18 of the metallic member 17, the disadvantages of the prior art arrangements are obviated since the bombardment of the surface 18 by the positive ions during the time in which the grid potential becomes excessively positive does not impair the operating characteristics of the device. In view of the above, it will be apparent that the effective or actual life of the discharge device will be determined by the amount of the eutectic mixture which can be packed into the molybdenum stocking which, in turn, is controlled principally by the physical dimensions by which the designer is limited.

By the optimum choice of the grid structure, particularly the size of the wires and the openings defined therebetween, the amount of grid emission may be kept under control. In addition, the planar heat shielding elements or members 35 and 36 in spaced relation between the dispenser element 19 and the grid 13 serve to limit the amount of radiant energy which is transmitted to the grid 13, thereby maintaining the temperature below that value which would tend to cause appreciable grid emission.

The spacing between the anode 4, the grid structure and the anode shield 10 is critically established in accordance with Paschen's law in order that the device may be capable of withstanding large forward voltages and large inverse voltages. Paschen's law refers generally to the relationship between the sparking or break-down voltage and the product of pressure of the medium and distance between surfaces of the elements. The spacing of the aforementioned elements of the discharge device is such that the maximum spacing or the distance between the remotest parts is such as to assure a large breakdown voltage or forward-voltage rating. It will be noted, by referring to the drawing, that substantially the same distance is maintained between the anode, the anode shield 10 and the grid 13 and supporting structures therefor. Furthermore, the spacing between the exterior surface of the shield 10 and the interior surface of the enclosing structure is of a relatively small value.

In accordance with one aspect of my invention, the spacing between the electrode structure and the enclosing envelope is maintained at a relatively small value thereby reducing the tendency to establish ionization between the electrode structure and the envelope. It will be noted that, for example, the spacing between the enlarged part 8 of the anode and the vitreous insulator 7 and the metallic member 6 is of a relatively small value compared with the total volume of the discharge device, or the transverse dimension thereof. If large spacings were employed, the volume becomes important and may cause deleterious effects incident to the production of ionization by stray electrons reaching into the vicinity of the glass-to-metal seals between parts 6 and 7, and 7 and 9. Such stray electrons in the absence of the optimum design which I provide would be instrumental in charging the glass within the region of the glass-to-metal seals. As an example, if the charge which is produced by such stray electrons establishes a potential difference of only 1 volt, in close proximity to the negative metal portion of the seal there may well be established a voltage gradient as large as 10^6 volts per centimeter, thereby causing field emission electrons to leave the metal surface resulting in undesired voltage breakdown. Accordingly, it will be appreciated that by reducing or minimizing the volume between the electrode parts and the envelope, particularly near the glass-to-metal seals, the tendency to produce ionization by the stray electrons within the region is substantially reduced or eliminated.

While I have disclosed and illustrated my invention as comprising an electric discharge device including elements having particular configuration, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In an electric discharge device comprising a plurality of enclosed electrodes including an anode, a cathode construction comprising a member concave towards the anode for providing an electron emissive surface, and a dispenser-type element lying within the concave region of said member for emitting activating material which is deposited on the surface of said member.

2. In an electric discharge device comprising a plurality of enclosed electrodes including an anode, a cathode construction which comprises a metallic member of the group including molybdenum and tungsten and having a configuration to provide a concave surface towards said anode and a dispenser-type element for continuously generating an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive.

3. In an electric discharge device including a plurality of enclosed electrodes comprising an anode, a cathode construction including a metallic member formed to provide a concave surface facing said anode and comprising a metal chosen from the group consisting of tungsten and molybdenum, a horizontally positioned dispenser element lying within the concave region of said member, and means for supplying heat to said dispenser element to cause the dispensation of activating material therefrom which is deposited on the concave surface of said metallic member thereby rendering it electron emissive.

4. A cathode construction for an electric discharge device including a plurality of electrodes comprising an anode and a cathode which includes a metallic member concave towards the anode and having therein a horizontally positioned dispenser element for producing an activating material which is deposited on the concave surface of said metallic member thereby rendering it electron emissive, said metallic member having a concave configuration such that a substantial portion of the radiant energy due to the heating of the dispenser element is reflected toward said dispenser element.

5. A cathode construction for an electric discharge device including an anode and a cathode which comprises a metallic member concave towards said anode and having positioned therein an elongated dispenser element including a eutectic mixture for dispensing an activating material which is deposited on the concave surface of said metallic member thereby rendering it electron emissive.

6. A cathode construction for an electric discharge device including a plurality of enclosed electrodes including an anode and a cathode which comprises a corrugated molybdenum pan-shaped metallic member concave towards said anode, and a dispenser element within the concave region of said member comprising a eutectic mixture for evolving an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive.

7. A cathode construction for an electric discharge device including a plurality of enclosed electrodes including an anode and a cathode which comprises a corrugated molybdenum pan-shaped metallic member concave towards said anode, a dispenser element within the concave region of said member comprising a eutectic mixture for evolving an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive, and electric insulating means for supporting said dispenser element in position.

8. A cathode construction for an electric discharge device including a plurality of electrodes comprising an anode and a cathode which comprises a metallic member having a configuration concave towards said anode, a dispenser element lying within the concave region of said member for producing an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive, and a heat shield surrounding said member and said element and extending an appreciable longitudinal distance towards said anode.

9. A cathode construction for an electric discharge device including a plurality of electrodes comprising an anode and a cathode which includes a metallic member concave towards said anode and having therein a dispenser element for producing an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive, and a metallic member positioned above said dispenser element in spaced relation between said anode and said dispenser element for limiting the heat flow from said dispenser element.

10. A cathode construction for an electric discharge device including a plurality of enclosed electrodes comprising an anode and a cathode which comprises a metallic member concave towards said anode, a horizontally positioned dispenser element within the concave region of said member for dispensing an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive, and a planar metallic member positioned above said dispenser element for limiting the heat flow from said dispenser element.

11. A cathode construction for an electric discharge device including a plurality of enclosed electrodes comprising an anode and a cathode which comprises a metallic member concave towards said anode, a horizontally positioned dispenser element within the concave region of said member for dispensing an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive, and a pair of longitudinally spaced planar metallic members positioned above said dispenser element for minimizing the heat flow from said dispenser element.

12. In an electric discharge device including a plurality of enclosed electrodes, the combination comprising an anode, a grid in spaced relation with said anode, and a cathode including a metallic member concave towards said anode and having within the concave region formed thereby a dispenser element for producing an activating material which is deposited on the concave surface of said member thereby rendering it electron emissive, and means for accelerating the initiation of an electrical discharge between said anode and said cathode comprising a starting wire supported by said grid and extending towards said cathode.

13. In an electric discharge device of the type employing an ionizable medium and including a plurality of enclosed electrodes, the combination comprising an anode, a grid in spaced relation with respect to said anode, and a cathode comprising a metallic member concave towards said anode having positioned within the concave region a dispenser element which produces an activating material which is deposited on the concave surface of said member, a planar metallic mem-member positioned above said dispenser element, and means for accelerating the initiation of an arc discharge between said anode and said cathode in accordance with the potential variations of said grid comprising a conductive member supported by the grid structure and extending towards said planar metallic member.

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