

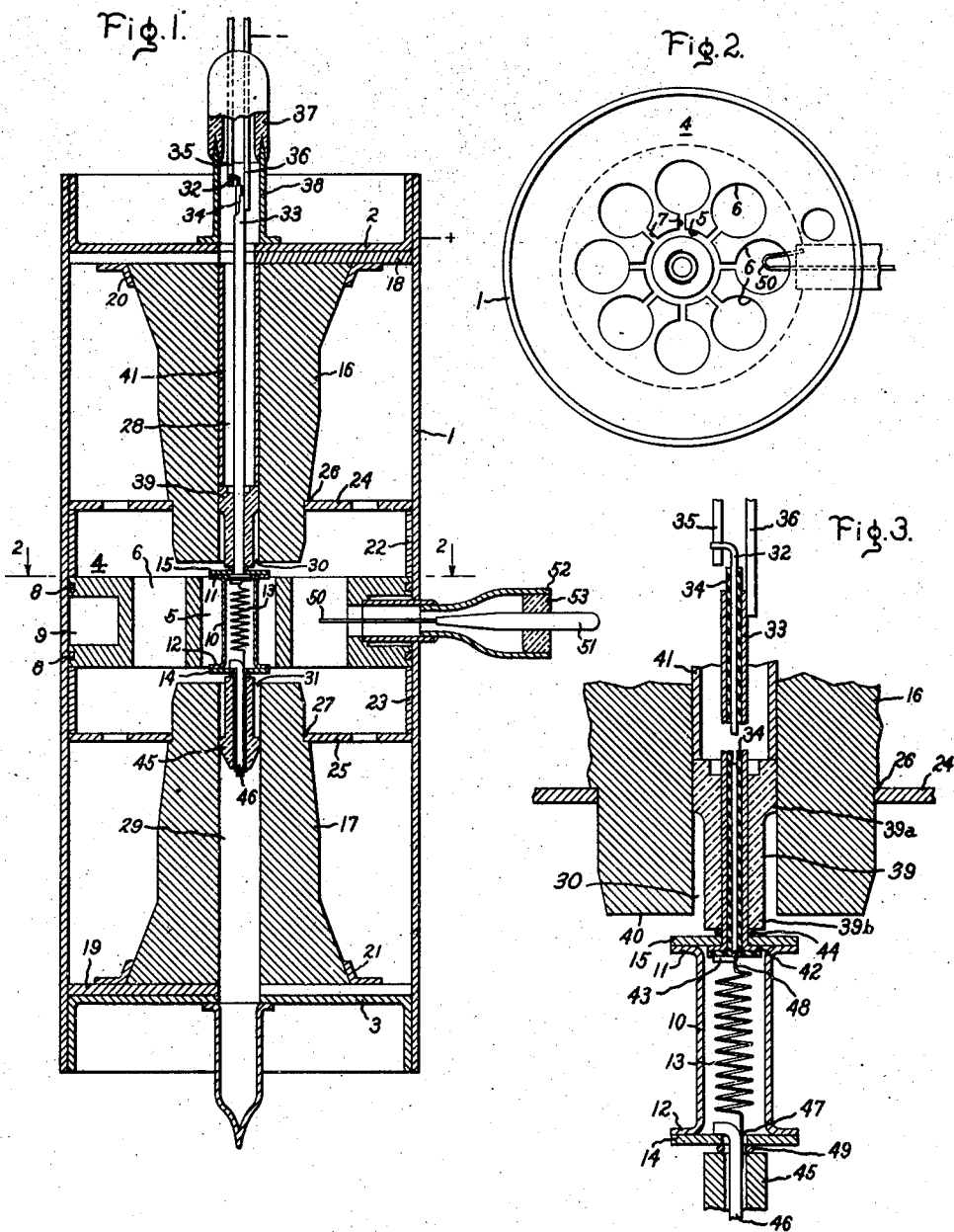
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ELECTRIC DISCHARGE DEVICE

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ELECTRIC DISCHARGE DEVICE

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8 Claims. (Cl. 250—27.5)

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My invention relates to electric discharge devices, and more particularly to the construction of space resonant electric discharge devices of the magnetron type.

In the widespread use of electric discharge devices of the magnetron type, it is important that there be a desired symmetry of elements, or electrodes, in order to obtain uniform energization of associated space resonant regions, or cavities, without sacrificing the power output of the device by a construction which causes the establishment of inordinately high voltage gradients across insulating parts of the structure which would require a reduction in the nominal power output, or cause damage to the elements, or electrodes, of the discharge device, thereby necessitating its withdrawal from use.

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 electric discharge device of the magnetron type.

It is another object of my invention to provide new and improved structure for supporting the elements of a magnetron of the space resonant type which permits operation of the device at relatively high voltages, and which does not disturb the desired symmetry of the electrostatic and magnetic fields required for satisfactory operation.

It is a still further object of my invention to provide new and improved cathode supporting structure for ultra high frequency magnetrons wherein shielding means are provided to prevent the deposition of conductive material on associated insulating structure.

Briefly stated, in the illustrated embodiment of my invention, I provide a new and improved ultra high frequency electric discharge device of the magnetron type comprising a space resonant region, or regions, energized in accordance with the oscillations, or motion, of the electrons constituting the space charge between an anode and a cathode, and in which the cathode is maintained in spaced relation with respect to the anode structure by means of an improved rigid cable construction, which affords rigid positioning of the cathode without entailing the establishment of excessively high voltage gradients across the insulating parts and which, by virtue of its symmetry, does not materially disturb the magnetic or electrostatic fields required for the most effective operation of the device, or system. In addition, shielding means are positioned relative to the cathode and the insulating structure to prevent the establishment of a conductive layer

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of metal or material thereon, and an appropriately positioned and designed insulator having a long leakage path is employed to eliminate or reduce the probability of an arc-over between the electrode structure and the associated magnetic pole pieces.

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 diagrammatically illustrates an embodiment of my invention as applied to an ultra high frequency magnetron of the type employing a metallic envelope or containing member and which includes a pair of permanently magnetized field members. Fig. 2 is a detailed view of the anode structure, and Fig. 3 is a detailed view of the suspending and centering insulator and cathode construction.

Fig. 1 of the accompanying drawing diagrammatically illustrates an embodiment of my invention as applied to an electric discharge device of the magnetron type employing a pair of magnetic field pieces oppositely disposed relative to a centrally located anode structure including a space resonant cavity, or cavities; and Fig. 2 is a detailed view of the anode structure.

Referring particularly to Fig. 1, there is shown an elongated cylindrical container the lateral wall structure of which is provided by a single metal envelope or containing member 1, preferably of tubular form, constructed of a ferro-magnetic material such as cold rolled steel, or the like. The ends of the container are enclosed by flanged members 2 and 3 which are welded or otherwise hermetically joined to the containing member 1. The outer surface of the envelope or member 1 may be provided with a plurality of heat dissipating means such as fins (not shown).

Within the containing member 1 and approximately at its central region there is provided an anode structure 4 shown in plan view in Fig. 2. The anode structure comprises a circular member which has a relatively large central opening 5 and a series of smaller openings 6 arranged symmetrically about the central opening 5. The central opening is joined to the openings 6 by means of a plurality of radially extending slots 7.

The anode structure 4, which preferably consists of copper, is supported by being brazed to the interior wall surface of member 1. To facilitate the brazing operation, small channels 8 are cut into the outer periphery of the structure 4, and these are used to receive rings of brazing material applied before the anode structure is

inserted within the containing member 1. A relatively large circumferentially extending channel 9 serves to reduce the overall weight of the structure.

Within the central opening 5 of the anode structure, I employ an indirectly heated cathode comprising a sleeve 10, of nickel or other suitable material, having flanges 11 and 12 at the ends thereof. This sleeve, which may be coated externally with a suitable activating material such as barium oxide, contains a filamentary heating element 13 by which the sleeve 10 may be maintained at an electron emissive temperature. One end of the cathode sleeve 10 is closed by a metal disc 14 and the other end of the sleeve is closed by an apertured disc 15.

The discs 14 and 15 have diameters of sufficient dimension to substantially shield insulating structure, to be described presently, to prevent the deposition of an appreciable conductive layer on the surface of the insulators, which would tend to reduce the operating voltage of the discharge device, or the system as a whole, since the conductive layer would tend to establish relatively low resistance leakage paths between elements at substantially great differences of potential. In the operation of the electric discharge device a space charge is developed in the space between the cathode sleeve 10 and the surrounding anode structure 4 by the application of a suitable potential impressed between the cathode structure and the containing member 1. The containing member 1, to which the anode structure 4 is directly connected, may have impressed thereon a unidirectional potential, such as a positive potential, and the other terminal for the unidirectional circuit is connected to the cathode structure by apparatus to be described presently.

The electrons which constitute the space charge are given a spiral or orbital motion by a magnetic field which is provided by electromagnetic structure, or by permanently magnetized field pieces to be described presently. The resultant gyrations or oscillations of the electrons constituting the space charge produce excitation of the anode structure at a frequency which is correlated to the natural frequency of the space resonant regions which is determined by the physical dimensions of the openings 6 considered in conjunction with the slots 7. The function of the anode structure in this respect may be explained from one point of view by considering that it is made up of a plurality of space resonant regions in each of which inductance is provided by a wall surface bounding one of the circular openings 6 and capacitance is provided by the opposing surfaces of one of the slots 7. Assuming this point of view, it will be seen that the operating frequency is in a large measure determined by the dimensions of the openings 6.

In order to provide a magnetic field of sufficient intensity to permit the apparatus to function in its intended manner, there are provided within the containing member 1 tapered magnetic pole pieces 16 and 17 which are directed axially of the containing member 1 and may extend in close proximity to the upper and lower surfaces of the anode structure 4. For present purposes, these pole pieces may be assumed to be permanently magnetized in such a sense that the north pole of one faces the south pole of the other.

To assure the existence of the magnetic field of the required intensity, the pole pieces 16 and 17 should be constructed of a magnetizable substance having a high coercive force and a high

energy factor. One of the materials which may be used for this purpose is that class of alloys including aluminum, nickel and cobalt. Alloys of this type are described, for example, in the Mishima Patents No. 2,027,994 to No. 2,028,000.

As a means for providing a low reluctance connection between the base ends of the magnetic pole pieces 16 and 17, the pole pieces may be respectively seated upon relatively thick disc-like members 18 and 19 constructed of ferro-magnetic material, such as steel. For the purpose of securing the pole pieces rigidly to the discs 18 and 19, I may employ clamping rings 20 and 21 slipped over the pole pieces and welded to the disc members.

The desired precise placement of pole pieces 16 and 17 with reference to the anode structure 4 may be obtained by the use of spacing rings 22 and 23. As will be observed from Fig. 1, each of these rings is interposed between one surface of the anode structure 4 and the surface of the apertured discs 24, 25, each disc in turn being in abutment with a properly positioned and formed shoulder on the adjacent pole piece as indicated at 26 and 27. The spacing rings 22 and 23 may be welded in place before the pole pieces are inserted within the containing member 1.

Pole pieces 16 and 17, inasmuch as these elements are positioned within the containing member 1, may be employed as supporting means for the cathode structure. This may be done, for example, by constructing the pole pieces 16 and 17 to have aligned central openings or centering channels 28 and 29, respectively, preferably of circular cross-section and which extend along the axial or longitudinal dimension of the pole pieces and afford communicating channels through which elements to be described presently extend or are positioned, and which present aligned openings 30 and 31 in the respective pole faces.

Referring to magnetic pole piece 16 in particular, I provide a relatively rigid concentric conductor construction for supporting the cathode centrally within the enlarged opening 5 of the anode structure 4, and which also is employed as a means or conduit for supplying energizing current to cathode heating element 13. Of course, one conductor of the cathode is also employed in connection with an external circuit by virtue of which a unidirectional potential is applied between the anode and the cathode. Considering more specifically the concentric cable construction, I provide a cable having an inner conductor 32 and an outer conductor 33, preferably constructed of a metal such as nickel or molybdenum, and which are maintained in spaced relation with respect to each other by a continuous insulator such as a tubular insulator 34. Conductors 32 and 33 are connected to externally accessible lead-in wires 35 and 36 which are sealed in a suitable insulator, such as a vitreous insulator 37. In order to facilitate the attachment of the insulator 37 to the body of the discharge device, and more particularly to the flange member 2, I may employ a cylindrical metallic member 38 which is welded or soldered to member 2 and sealed to conductor 37.

I provide within the channel 29 an insulator 39, the details of which are shown in Fig. 3. Insulator 39 serves as a supporting and centering means for the concentric cable comprising conductors 32 and 33 and closely fits the channel wall by virtue of the part 39a thereof which closely engages and is fitted to the channel wall.

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Insulator 39 is located near the end of channel 28 in the vicinity of the cathode and is provided with a section 39b of restricted diameter and which extends beyond the pole face 40 of magnetic pole piece 16. In order to place and maintain the insulator 39 in the desired axial position, I provide a tubular spacing member 41 in abutment with the insulator 39 and extending therefrom to the base of magnetic pole piece 16 where it engages or abuts the disc 18. The member 41 is closely fitted to the surface of the channel wall and serves as a means for preventing undesired axial movement of the insulator 39 and the associated cathode construction.

The concentric conductor also serves as a means for supplying current to the cathode heating element 13, and the outer conductor 33 also serves as a means for impressing a potential, such as a negative potential, on the cathode. Conductor 33 may have a flanged part 42 at its lower end to engage firmly disc 15, and the inner conductor 32 may be bent over, as shown at 43, to prevent undesired axial movement or stress of the inner conductor relative to the insulating member 34 which is interposed between part 43 and the flanged part 42 of outer conductor 33. A spacing ring 44, preferably constructed of nickel, is placed between insulator 39 and the upper surface of disc 15, all of these members being in close contact and engagement so that the heat transfer from the cathode to the insulators 39 and 45 is minimized.

It will be noted that the restricted part 39b of insulator 39 affords an appreciable annular space between its surface and the wall of channel 28, thereby providing a long leakage path between the cathode structure and the pole piece 16. In this manner, even though the conductive layer tends to be deposited on part 39b of insulator 39, there is nevertheless afforded a sufficiently long leakage path to reduce or minimize the probability of arc-over between pole piece 16 and the cathode structure.

Within the channel 29 of magnetic pole piece 17, I provide an insulator 45 which centers the lower end, and particularly disc 14, of cathode construction and supports a metallic pin 46 which is turned over at its upper end and to which the lower terminal 47 of cathode heating element 13 is welded or soldered. The upper terminal 48 of the cathode heating element is welded or soldered to the inner conductor 32. I also employ between disc 14 and insulator 45 a metallic ring, such as a nickel ring 49, for firmly maintaining the cathode construction and the insulator 45 in the desired fixed spaced relation and for minimizing heat transfer. Inasmuch as insulator 45 is firmly positioned against the wall of channel 29, it will be appreciated that axial as well as radial movement of the cathode construction is prevented.

As a means for extracting energy from the discharge device, I may employ an output electrode means, such as a loop 50, extending into one of the openings 6 and which may constitute an extension of a center conductor 51 of a concentric transmission line comprising conductor 51 and an outer conductor 52 which are sealed by means of a glass or vitreous seal 53.

Upon the application of a unidirectional voltage between the anode structure and the cathode, the electric discharge device effects energization of the various space resonant regions, comprising openings 6 and slots 7, to supply ultra high frequency energy to a utilization circuit

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which may be connected to the concentric transmission line comprising conductors 51 and 52. The various space resonant regions, or cavities, are excited or energized in accordance with the oscillations or motions of the electrons constituting the space charge within the region defined by the cathode sleeve 10 and anode structure 4. The period of oscillation of the electrons constituting the space charge, or a portion thereof, is correlated with respect to the natural resonance frequency of the various space resonant regions comprising openings 6 and slots 7 to maintain the regions in oscillation, and energy may be derived from all the regions through the loop 50 and conductors 51 and 52.

Discs 14 and 15 shield insulators 45 and 39, respectively, from the cathode and thereby prevent the electrons from striking the insulators, which would otherwise be the case due to the axial movement of those electrons which pass beyond the boundaries defined by the top and bottom surfaces of anode structure 4. Even though the sides of the insulators collect any conductive coating incident to the relatively high temperature of the cathode, the increased length of leakage path will prevent breakdown which would otherwise result from creepage along the surface of an improperly positioned and designed insulator.

Another advantage of the construction which I provide is that the insulating paths, particularly that of insulator 39, with respect to ground are many times greater than that afforded by the prior arrangements, and consequently for a given applied voltage it is possible to use materials having a somewhat smaller dielectric strength. Furthermore, by virtue of the above described construction, the tendency to produce short circuits in the cathode assembly is materially decreased since the two terminals or conductors for the cathode heating element 13 are well insulated from each other and are of strong mechanical construction.

Some of the other advantages incident to my above described construction for the electric discharge device include ease of mechanical assembly made possible by the simplicity of construction, particularly the single upper insulator and the rigid concentric cable. In addition, the generally symmetrical configuration of the elements, or electrodes, of the discharge device and the associated conductors and insulators reduces the possibility of establishing excessively high or dangerous voltage gradients which would ordinarily tend to be present at the ends of channels 28 and 29 facing the anode structure 4.

Certain features of the electric discharge device shown in Fig. 1, including the metallic containing member and the permanently magnetized magnetic field members, are disclosed and broadly claimed in a copending patent application of Elmer D. McArthur, Serial No. 447,903, filed June 22, 1942, and which is assigned to the assignee of the present application. Other features relating to certain aspects of the rigid cable construction are disclosed and broadly claimed in copending patent application Serial No. 465,424 of Ralph J. Bondley, filed concurrently herewith and which is also assigned to the assignee of this application.

While I have shown and described my invention as applied to a device embodying various elements diagrammatically shown, 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. An electric discharge device comprising a plurality of enclosed co-operating electrodes including an anode structure having a centrally located opening therein and a cathode, a pair of magnetic pole pieces positioned on opposite sides of said anode structure and each including a channel lying longitudinally of the pole piece and being aligned with respect to each other and with respect to said opening, a pair of insulating means each positioned in one of said channels and each having a portion engaging the walls of the channel at a region spaced from the pole face and a second portion extending from the channel beyond the pole face, said last mentioned portion having a smaller cross section than the channel, and means extending through said insulating means supporting and centering said cathode.

2. An electric discharge device comprising a plurality of enclosed co-operating electrodes including a thermionic cathode including a heating element and an anode structure surrounding said cathode, a pair of magnetic pole pieces spaced on opposite sides of said anode structure and each having therein a channel of circular cross section positioned longitudinally of the pole piece, means supporting said cathode and for supplying current to said heating element comprising a concentric cable construction including an inner and outer conductor extending through the channel of one of said pole pieces, an insulator fitted in the channel of said one pole piece centering and supporting said cable, and a tubular spacing member extending from the vicinity of said insulator toward the base of said one pole piece.

3. An electric discharge device comprising a plurality of co-operating electrodes including a cylindrical cathode and an anode structure of annular form having therein a central opening within which said cathode is positioned, a pair of magnetic pole pieces spaced on opposite sides of said anode structure, said pole pieces each having therein a channel positioned longitudinally of the pole piece, a rigid cable construction lying within the channel of one of said pole pieces supporting said cathode, an insulator in said channel near the end thereof facing said anode structure supporting and centering said cable, a second insulator in the channel of the other pole piece and including a member centering said cathode, and a pair of shielding members at the ends of the cylindrical cathode to prevent the deposition of conductive material on said insulators.

4. An electric discharge device comprising a plurality of co-operating electrodes including a cathode having a cylindrical sleeve provided with an electron emissive surface and an annular anode structure having therein a central opening within which said sleeve is positioned, a pair of magnetic pole pieces spaced on opposite sides of said anode structure, said pole pieces each having therein a channel extending longitudinally of the pole piece, a rigid cable construction lying within the channel of one of said pole pieces supporting said cathode and comprising an inner member and a concentric tubular outer member, a cathode heating element substantially surrounded by said sleeve and having one terminal conductively connected to said inner conductor, an insulator

positioned within the channel of the other pole piece near the region of the pole face, and a metallic pin positioned by said insulator and connected to the other terminal of said cathode heating element and said cathode.

5. An electric discharge device of the magnetron type comprising a plurality of enclosed co-operating electrodes including a thermionic cathode including a cylindrical sleeve coated with an electron emissive material and a cathode heating element within said sleeve, an anode structure of general circular configuration provided with a circular center opening within which said cathode is positioned and including a space resonator to be energized in accordance with the motion of the electrons constituting the space charge between said cathode and said anode structure, a pair of magnetic pole pieces respectively positioned on opposite sides of said anode structure for establishing a magnetic field within the space defined by said cathode and said anode structure and each having therein a channel positioned longitudinally of the pole piece, means supporting said cathode comprising a concentric cable extending through the channel of one of said pole pieces and including an inner conductor, an outer concentric tubular conductor and an insulating material therebetween, an insulator positioned in the channel of one of said pole pieces and in close engagement therewith supporting and centering said cathode, means connecting one terminal of said cathode heating element to said outer tubular conductor, means comprising a pin connecting the other terminal of said cathode heating element to said cathode structure and constituting a part of an energizing circuit for said cathode heating element, a second insulator positioned within the channel of the other pole piece and centering said pin, and a pair of shielding members closing the ends of the cathode sleeve and of dimensions sufficient to shield said insulators to prevent the deposition of conductive material thereon incident to the vaporization of electrons from the emissive surface of said cathode.

6. An electric discharge device comprising a plurality of enclosed co-operating electrodes including a cathode and an anode structure surrounding said cathode, a pair of magnetic pole pieces spaced on opposite sides of said anode structure, said pole pieces each having therein a channel positioned longitudinally of the pole piece, means positioning said cathode comprising a concentric cable construction attached to said cathode and extending through the channel of one of said pole pieces, an insulator supporting and centering said cable and closely engaging the channel wall of said pole piece, and a copper sleeve in abutment with said insulator and closely fitted to the channel wall and extending from said insulator to the base of said one pole piece.

7. An electric discharge device comprising a plurality of co-operating electrodes including a cathode and an anode structure surrounding said cathode, a pair of magnetic pole pieces spaced on opposite sides of said anode structure and each having therein a channel of circular cross section positioned longitudinally of the pole piece, means positioning said cathode comprising a concentric cable construction attached to said cathode for supplying current to a cathode heating element and extending through the channel of one of said pole pieces, an insulator centering and supporting said cable located within the channel within the vicinity of said cathode and

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in close engagement with the channel wall, and a metallic tube in abutment with said insulator and extending therefrom to the base of said one pole piece.

8. An ultra high frequency electric discharge device comprising a plurality of enclosed co-operating electrodes designed to have electrical and geometrical symmetry about a longitudinal axis and comprising a cylindrical thermionic cathode and an annular anode structure provided with a circular central opening within which said cathode is positioned, a pair of magnetic pole pieces spaced on opposite sides of said anode structure and having pole faces of substantially circular cross section, said pole pieces each having therein a channel of circular cross section positioned longitudinally of the pole pieces and

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in alinement with each other, means supporting said cathode comprising a rigid concentric cable construction including spaced inner and outer conductors and extending through the channel of one of said pole pieces, an insulator in close engagement with the channel wall of said one pole piece and extending beyond the pole face thereof in the direction of said cathode, a centering insulator in the channel of the other pole piece and supporting a metallic pin in electrical contact with said cathode, and a pair of shielding discs positioned between said cathode and said pole faces to prevent the deposition of conductive material on said insulators incident to the vaporization of electrons from the emissive surface of said cathode.

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