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Thomsen

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[54] **ARC LAMP WITH MAGNETIC VORTEX ANODE**

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[73] Assignee: **The United States of America as represented by the Secretary of the Army**

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[52] **U.S. Cl.** **313/30,** 313/155, 313/161, 313/224

[51] **Int. Cl.**.....**H01j 61/52,** H01j 1/50

[58] **Field of Search**.....313/30, 155, 161, 224

[56] **References Cited**

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[57] **ABSTRACT**

An elongated hollow section cylindrical anode for use in a high pressure xenon short arc lamp. The cylindrical anode has an enlarged open axial passage extending therethrough. A strap of conductive material is wound within the hollow section to produce a high intensity magnetic field about the anode when the arc lamp is operating. The surface contour of the anode and the diameter of the axial passage therethrough are such that the high intensity magnetic field interacts with electrons in the arc column creating a vortical motion of the arc. The vortical motion of the arc disperses the footpoint of the arc along the anode walls of the axial passage, providing for greater heat dissipation and power handling capability.

5 Claims, 3 Drawing Figures

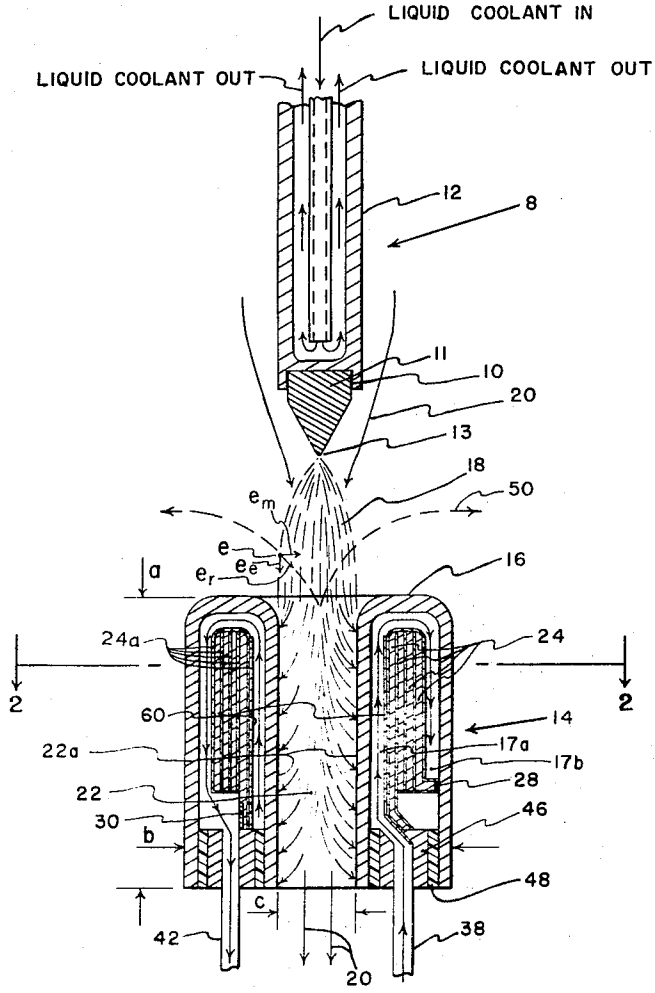
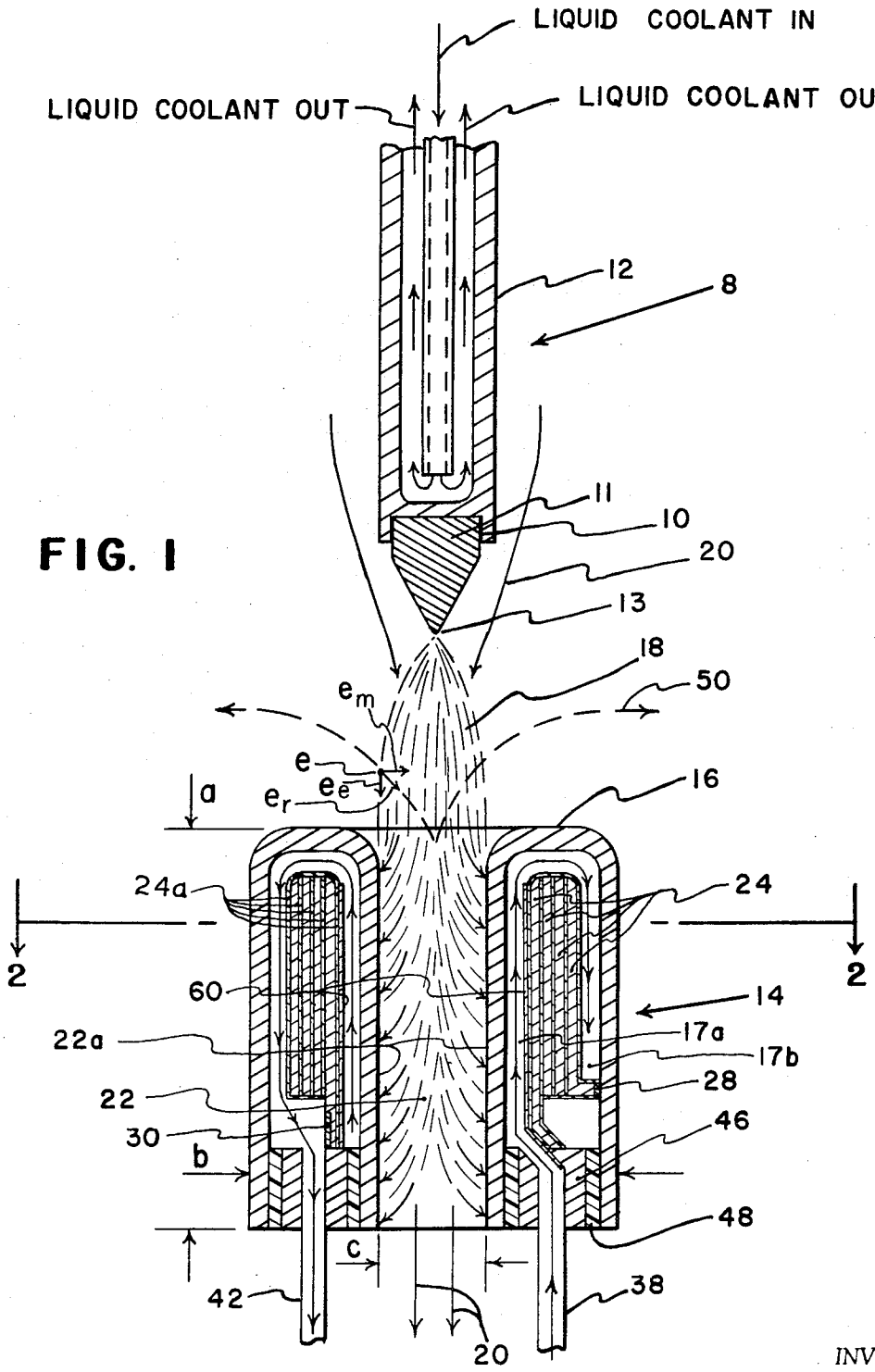


FIG. 1



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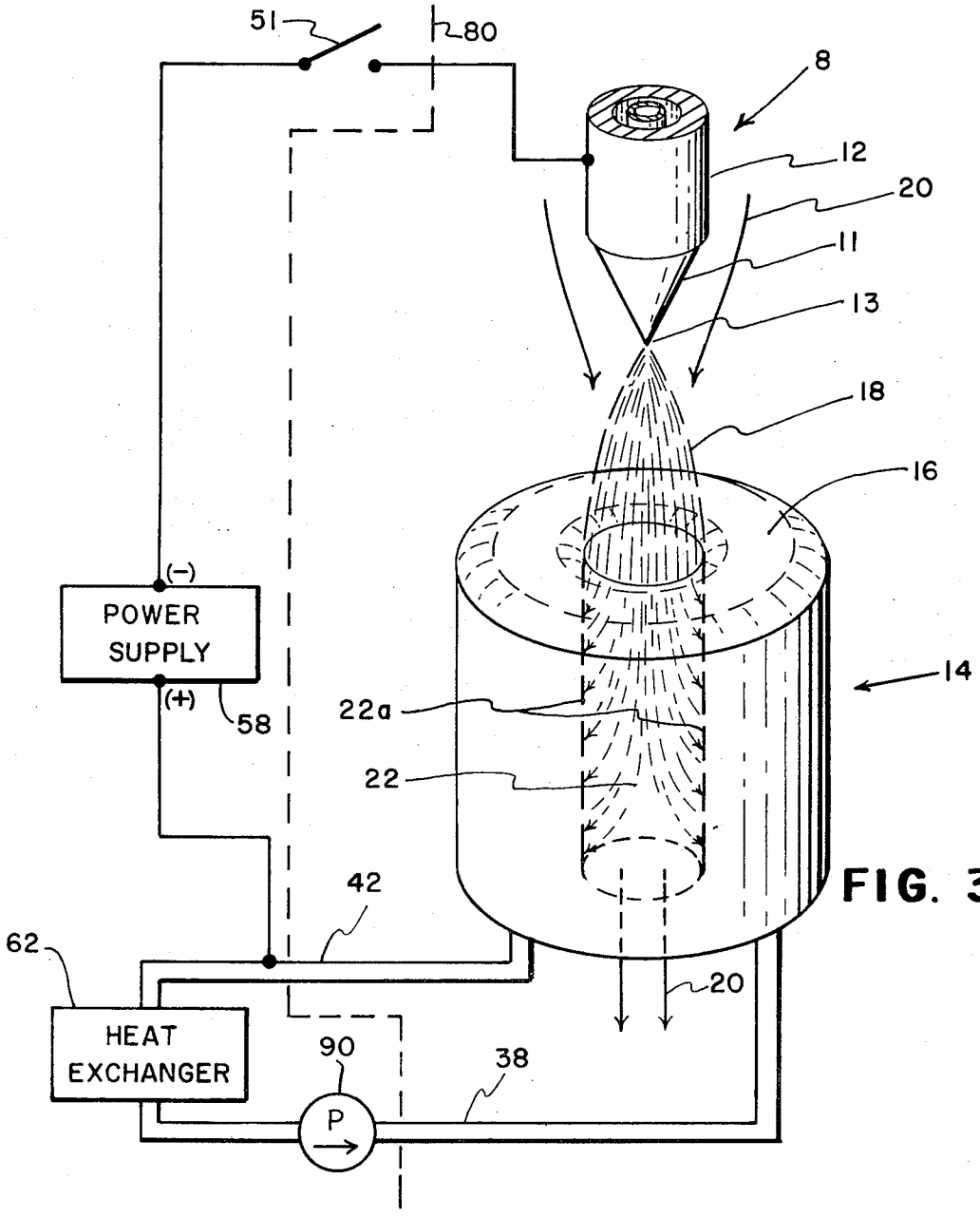


FIG. 3

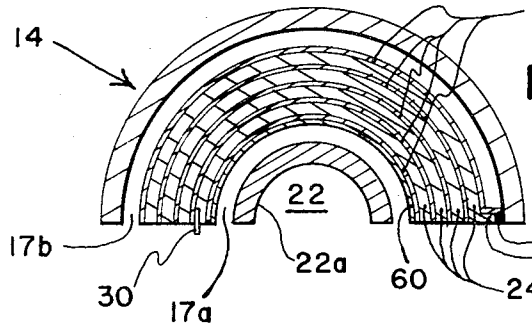


FIG. 2

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ARC LAMP WITH MAGNETIC VORTEX ANODE

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to me of any royalties thereon.

BACKGROUND OF THE INVENTION

The small operation power and the short lifetime of the arc lamps are limiting factors in conventional liquid cooled arc lamp anodes for withstanding the very high concentrated heat loads normally produced at the footpoint of the arc. In the operation of conventional liquid cooled anodes arc power is concentrated over a small area of the anode surface. The intense heat produced at this small area, called the footpoint of the arc, causes severe problems in the anode material and in the fluid dynamics of the coolant liquids circulated through the anode.

There is, therefore, a great need for an apparatus and means of spreading this footpoint over a much larger area of the anode surface. The present invention solves this problem by providing an elongated hollow section cylindrical anode having an enlarged axial passage and a strap of conductive material wound inside the hollow section for providing a magnetic field about the anode. The hot gas and accompanying arc column pass completely through the axial passage, causing the arc to dissipate over a much larger surface area of the anode.

SUMMARY OF THE INVENTION

The anode of the present invention is an elongated cylinder having a hollow section that is enclosed at one end, is open at the other end, and has a large axial passage therethrough. The enclosed end is adjacent the cathode. The center of the axial passage, and of course the center of the anode since the anode is cylindrical, is along the arc lamp axis. The cathode is also along the arc lamp axis. A solid strap of conductive material is wound around the hollow section of the anode. The strap is supported by a piece of thin walled copper pipe that is attached to the liquid coolant pipes. An open portion remains between the strap and the shell of the cylindrical anode for circulation of a liquid coolant therethrough. The coolant is circulated through the anode by entering through three entrance pipes and exiting through three exit pipes. The pipes are evenly spaced through the open end of the cylindrical anode. The three entrance and exit pipes, made of conductive material, are sealed water tight and are electrically isolated from the anode by an insulator fitted around the open end of the anode. One end of the strap of conductive material is connected to the cylindrical anode and the other end is connected to one of the plurality of conductive pipes. The positive terminal of a power supply is connected to the conductive pipe which has one end of the strap connected thereto. The negative terminal is connected to the cathode of an arc lamp within which the novel anode is used.

When the arc lamp is operating, a magnetic field is automatically provided around the anode by current flowing through the strap from anode to the conductive pipe. A magnetic field is produced within the axial passage parallel to the lamp axis, but the magnetic field diverges at the end of the passage. Thus, the electrons traveling from the cathode that disperse out from the lamp axis must cross the magnetic field lines to reach the anode. The interaction of the magnetic field with the moving electrons produces forces on the electrons according to the "right hand rule" with the forces having components toward the lamp axis and components perpendicular to the lamp axis. The components perpendicular to the axis produce a rotational torque, or motor force, which imparts a spin to the arc column and the entire gas jet in which the arc column is being transported.

The arc column is, therefore, carried through the axial passage on a spinning jet of incandescent gas. The combined action of the gas motion and the magnetic field distributes the electrons, which form the arch column, along the axial passage wall over a much larger area than has been possible in prior art short arc lamp anodes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of the anode structure facing the cathode in working order;

FIG. 2 is a sectional view through 2—2 of FIG. 1; and

FIG. 3 is a diagrammatic view of the anode positioned facing the cathode showing internal and external power supply and liquid coolant connections.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, cathode 8 is in workable position with cylindrical anode 14. Cathode 8 may be any commercially available cathode that has the proper specifications. The anode, however, is novel in that it has an increased axial passage through its center and a means of producing a larger magnetic field by use of a large strap of conductive material 24 wound inside the anode. The strap of conductive material is connected in series with the anode, a conductive pipe, a power supply, and the cathode. Therefore, one power supply causes the ejection of electrons from the cathode and also current flow through the strap producing a large magnetic field about anode 14. When the lamp is activated, electrons in the arc are acted upon by the large magnetic field, causing forces according to the "right hand rule" with the result that the arc is set in a vortical motion through the axial passage.

Arc current 18, ejected from cathode 8 and striking anode 14, is guided through axial passage 22 of cylindrical anode 14 by interaction of the moving electrons in 18 with magnetic flux lines 50 produced by current flowing through conductive strap 24. Strap 24 is conductively connected to shell 16 of anode 14 by brazing at junction 28 and is connected to conductive pipe 42 by brazing at junction 30. Referring now to FIGS. 1 through 3, power supply 58 has it positive terminal connected to coolant exit pipe 42 and its negative terminal connected to cathode 8. With switch 51 closed and the arc lamp in operation, electrons in arc 18 are deposited on anode 14. With positive voltage of power supply 58 applied to pipe 42, a heavy current will flow through strap 24, establishing a magnetic field of flux lines 50 around the coil formed by overlapping layers of 24. Therefore, when switch 51 is closed the power circuit of the short arc lamp is connected from cathode through the conductive pipe and conductive strap to anode with the electron current flowing through

cathode 8, arc 18, anode 14, strap 24, pipe 42 and back through power supply 58 and switch 51. With current flowing in this manner, magnetic flux lines 50 will flow in the direction shown by the arrows in FIG. 1. Gas 20 is some inert gas such as xenon but is not limited to xenon. Arc 18 is initially started through passage 22 by flux lines 50 reacting with electron arc 18 according to the "right hand rule." This phenomenon may be observed with reference to a point at the outer left side of arc 18 of FIG. 1 which illustrates a single electron, *e*, moving from cathode 8 to anode 14 in the vector direction of e_e. The force on electron, *e*, according to the "right hand rule" is in the vector direction represented by e_m. The resultant direction of electron, *e*, is in the general of e_r, or diagonally back toward the arc lamp axis which passes through the center of passage 22. Electron, *e*, merely represents one electron out of a mass of electrons in arc 18. All of these mass of electrons in arc 18 are acted upon by flux lines 50. The only exception to this is the electrons that travel along the arc lamp axis where there is a magnetic neutral because of the symmetrical magnetic field on all sides along the lamp axis. Arc column 18 is distributed along walls 22*a* of axial passage 22 by the flow of gas 20. The arc is therefore set in motion in a vortex pattern and electrons of the arc are compressed along the axial passage 22 of the anode. Arc 18 is distributed over a much larger area of the anode when it passes through passage 22, therefore, the power handling capabilities of the arc lamp using the novel anode is greatly increased.

A plurality of entrance and exit pipes 38 and 42, respectively, (only one of each being shown in FIGS. 1 and 3) are used for passing a coolant liquid through anode 14. Liquid coolant enters anode 14 by entrance passage 17*a*, circulates around the inner portion of the anode and exits through passage 17*b*. Refer to FIGS. 1 and 2 for a better illustration of how the liquid coolant enters the entrance passage 17*a* and exits through passage 17*b*. Passages 17*a* and 17*b* have a diameter of 11 millimeters measured between strap 24 and the inner shell of anode 14. The diameter of pipes 38 and 42 are 9.5 millimeters. Strap 24 is typically 30 mils thick and 38 millimeters wide and is insulated by sheet mica insulation 24*a*. Strap 24 is wound around a piece of thin wall copper pipe 60 about four or five turns. Copper pipe 60 is attached to and forms an extension of the three entrance pipes 38. The sheet mica insulation 24*a* insulates adjacent turns of strap 24 from each other and from pipes 38 and 42. Also, strap 24 is insulated from liquid coolant flowing through passages 17*a* and 17*b*. Normally the liquid coblant used is water and does not deteriorate the mica insulation. Further, pipes 38 and 42 and strap 24 are insulated from anode 14 by an insulator ring 46 made of a material such as hard rubber. Insulator ring 46 is positioned around the open end of anode 14 and is held by epoxy seal 48.

Refer to FIGS. 1–3 for operation of the cylindrical anode 14 in a typical short arc lamp of about 30 kilowatts rating. Anode 14 is cooled during operation by a liquid coolant, such as water, being circulated through the anode. The liquid coolant is pumped by pump 90 into anode 14 through three entrance pipes 38 and out three exit pipes 42 (only one of each being shown in FIGS. 1 and 3). Pipes 38 and 42 are alternately positioned 60° apart around insulator ring 46 and pass through ring 46 into passages 17*a* and 17*b*. A relatively uniform flow of liquid coolant within the anode is assured with the pipes positioned symmetrically in this manner. The liquid coolant removes the heat of the arc deposited on the anode and returns to a heat exchanger 62 for dissipating heat from the liquid and returning through pump 90 for recirculation through the anode. The flow pattern within anode 14 is shown by arrows in FIG. 1.

Strap 24, made of some conductive material such as copper, conducts heavily when the short arc lamp is in operation. Looking now at FIGS. 1 and 3, power supply 58 is connected to cathode 8 through switch 51 and to anode 14 by way on one of the exit pipes 42. Power supply 58, therefore, not only furnishes power for the arc lamp but also furnishes magnetizing current through straps 24 that are wound in a coil to produce a magnetic field about anode 14. Dashed line 80 of FIG. 3 illustrates the elements external to the arc lamp on the left of the line and elements within on the right side of line 80.

Dimensions of the anode are typically as follows. The overall length, *a*, is 46 millimeters. The inside diameter, or the axial passage 22 diameter, *c*, is 11 millimeters. The outside diameter, *b*, is 38 millimeters. The dimensions of cathode 8 used in successful operation of anode 14 are as follows. Molybdenum shell 12 encloses tungsten tip 11 by high temperature brazing around the shell and tip at 10. The diameter of tungsten tip 11 is 17 millimeters. The length of 11, i.e., from tip 13 to the back portion that fits against 12, is 22 millimeters. The coolant enters through a center pipe and exits on all sides of the center pipe as shown in FIG. 1. With the conventional cathode of the above size being operated with the novel anode, the position of each one to the other is as follows. Tip 13 is about 16 millimeters from a point along the lamp axis that intersects outer surface 16 of anode 14. The solid portion of tip 13 is a 60° angle truncated cone.

I claim:

1. An improved short arc lamp enclosed in a glass tube enclosure having two ends therein for providing a generally elongated arc chamber, one end of the arc chamber containing a cathode and the other end of said arc chamber containing an anode for providing an arc current between the cathode and the anode wherein the improvement comprises:

an elongated hollow section cylindrical anode closed at the end adjacent the cathode and open at the opposite end and having an enlarged axial passage that is only slightly smaller in diameter than the cathode and being centered along the arc lamp axis; and

means including magnetic flux producing means within said anode for distributing heat of the arc current from said cathode along the surface of said axial passage.

2. An improved short arc lamp as set forth in claim 1 wherein said magnetic flux producing means includes a solid strap of conductive material wound within said elongated hollow section cylindrical anode leaving a passage between said strap and the shell of said anode.

3. An improved short arc lamp as set forth in claim 2 wherein said means further includes:

a plurality of conductive entrance and exit pipes entering said anode through insulation in its open end for circulating a liquid coolant through said passage between said strap of conductive material and the shell of said anode for removing heat from said anode;

one end of said strap of conductive material connected to the shell of said anode and the other end of said strap connected to one of said conductive pipes; and

a power supply having its positive terminal connected to the one conductive pipe which said other end of strap is also connected and having its negative terminal connected to said cathode wherein said power supply causes electron arc current to flow from cathode to said anode thereby applying a negative voltage to the anode causing a heavy current to flow through the strap between the negatively charged anode to the positive terminal of said power supply thereby producing a large magnetic field perpendicular to the electron movement of the arc current causing vortical motion of the arc current and thereby distribution of said arc current along the surface of the axial passage.

4. An improved short arc lamp as set forth in claim 3 wherein said strap of conductive material is a copper sheet 30 mils thick and 38 millimeters wide that is wound four turns inside the hollow section of said cylindrical anode.

5. An improved short arc lamp as set forth in claim 4 wherein said axial passage is 11 millimeters in diameter, the outside diameter is 38 millimeters and the overall length is 46 millimeters when used with a cathode of 17 millimeters diameter with a truncated tip of said cathode positioned 16 millimeters from the end of the anode adjacent said cathode.

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