

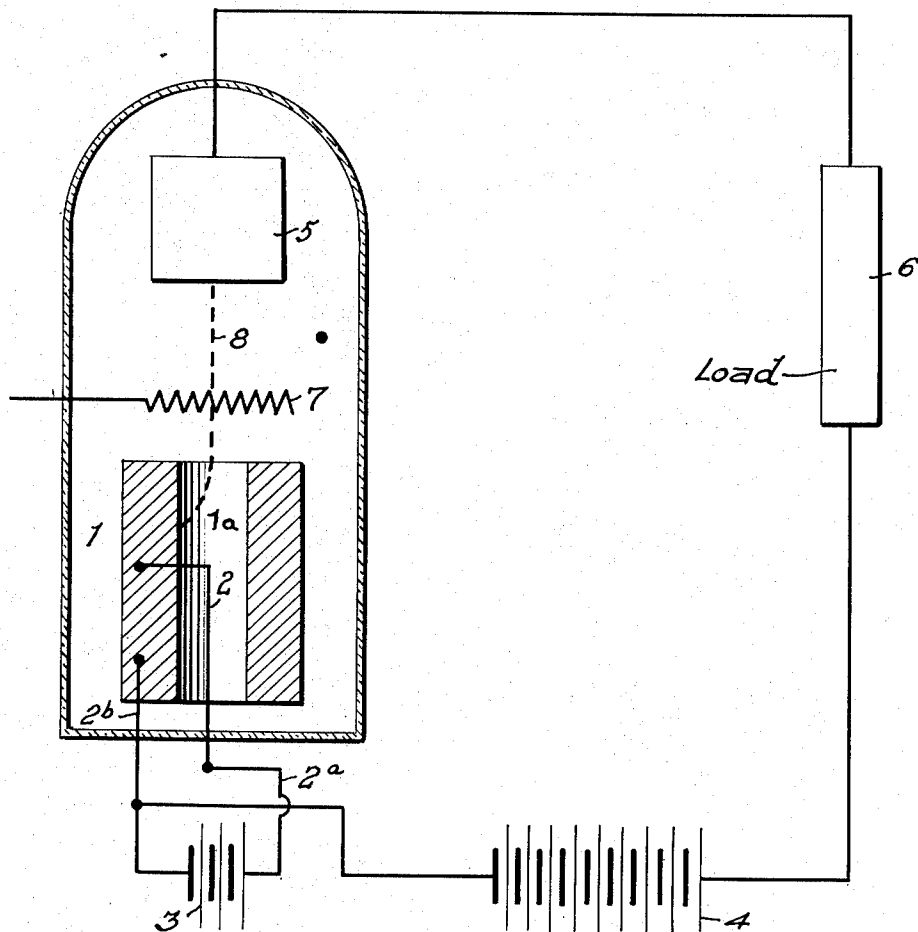
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CATHODE SPOT EXCITATION

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CATHODE SPOT EXCITATION

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The invention described in the specification and claims may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to gaseous discharge tubes and particularly to such a tube capable of handling very large currents.

In the electronics art, gaseous discharge tubes are commonly used as relay devices, wherein the application of a small voltage to the grid of a tube, or a small additional voltage in excess of a critical voltage to the anode of a tube, causes a large amount of current to flow in the tube and its associated circuits. In any case, the current, of course, consists of electrons passing from the cathode to the anode. Current, therefore, is limited by a number of factors, two of the most important being: first, the ability of a cathode of convenient size to emit the requisite quantity of electrons; and, second, the ability of the tube and its elements to dissipate the heat caused by the passage of the current.

My invention consists of a novel type of cathode, as hereinafter described. I make use of a small directly heated cathode which forms part of a larger cathode. The larger cathode does not require heating as is usually understood, but releases a large quantity of electrons when such cathode is subjected to ion bombardment. The formation of a highly emissive spot under such conditions is termed "cathode spot excitation."

My method of producing cathode emission by spot excitation differs from the usual thermionic cathode in several ways, and affords the following advantages:

a. My excited spot cathode makes it possible for gaseous discharge tubes to act as conductors for several tens of thousands of amperes, a condition not obtainable when the conventional thermionic cathodes are used.

b. It is not essential, after spot initiation that my excited spot cathode be heated by an external source, such as is required to maintain excitation of a thermionic cathode.

c. My cathode is so designed, through the use of refractory conductive materials and/or a means of keeping the spot in motion, that its life is not greatly decreased by action of the cathode spot.

d. My cathode is made of materials which are not only conductive and resistant to attack by the cathode spot, but which also facilitate electron emission and spot formation.

e. My cathode is so shaped as to provide a local voltage drop which accelerates the emitted electrons and the received ions. This may be done, for example, by constricting the cross section of the discharge near the source of initiating electrons.

f. The major advantage provided by my excited spot cathode is that it affords an extremely high upper limit of current for a given cathode size. For example, the possible output from my cathode is of the order of 2,000 to 4,000 amperes per square centimeter as compared to a maximum output of 1 to 5 amperes per square centimeter for the conventional oxide-coated thermionic cathode.

g. Because only a portion of my cathode is heated by an external source, less external power is required for heating a cathode of given power output, as compared with the conventional thermionic cathode.

h. As the electron-emissivity of my cathode is not dependent upon a coating on the surface of the material, but exists as well if the surface layer is removed, it affords

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longer working life than will the usual oxide-coated cathode.

i. Because of its more rugged construction, my cathode is less subject to damage due to short circuits or other circuit faults.

The specific nature of the invention as well as other objections and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawing, in which the single figure is a schematic drawing of a circuit including a gaseous discharge tube illustrating the principle of my invention.

In the single figure, there is represented a cathode, the major portion of which 1 is made of some such refractory material as sintered tungsten and some such insulating material as thoria in proportions of the order of 3 parts tungsten to 1 part thoria, using standard techniques, such, for example, as described in "Thermionic emission from sintered cathode," by H. J. Fan; Journal Applied Physics, July 1949, pages 682-690. Other refractory materials may also be used, such as thorium-molybdenum or thorium-rhenium. These parts are well mixed, and shaped under pressure substantially to the configuration shown. Within this major portion there is located a small thermionic portion 2 of the cathode, one end of which is affixed and connected to the major portion 1, the other end being connected by means of a lead 2a to a source of heating current 3, the circuit from this source of heating current being completed to the major portion 1 of the cathode through an additional lead 2b.

Positioned approximately as shown in the figure is an anode 5, which is connected to the operating load 6, and thence to a source of electrical power 4, the circuit being completed back to the cathode through a lead to lead 2b. The gas used in the tube may be any suitable gas and in the usual pressure range commonly used for gas-filled thyratrons. A control grid 7 may be supplied for certain types of operation, as is well known.

Operation takes place when a suitable voltage is applied as shown at 4. When this voltage is below the critical voltage, the tube is non-conductive, the space between cathode 1, 2, and anode 5 forming an open circuit. When, however, the voltage applied to the circuit at 4 is in excess of the critical voltage, a conductive path is formed between 1, 2, and anode 5. Similarly, the critical voltage can be reached with a lower applied voltage at 4 if current is caused to flow from source 3 through the smaller portion of the cathode 2.

The action may be described as follows:

When cathode portion 2 is heated by the passage of electric current from source 3, electrons are emitted from cathode portion 2. These electrons are attracted by the positive bias on anode 5. Their passage through the gas which fills the cavity in portion 1 of the cathode, and the space between this part and the anode 5, causes ionization of such gas. Both positive and negative ions and electrons are produced; the electrons are attracted to the anode, causing more collisions with gas molecules, and thus further ionization; the positive ions are attracted to the cathode portion 1 by the negative charge resident thereon.

This bombardment of portion 1 by the ions causes an arc cathode spot to be formed in region 1a; this spot emits a beam of electrons 8 from cathode portion 1 to anode 5.

The formation of a cathode spot in region 1a is facilitated by two features of this invention:

(1) The presence of insulating particles embedded in the cathode produces local high electric field concentrations. This is caused by a charge built up on the insulating particles by bombardment of positive ions. Such high fields are known to cause the formation of a cathode spot.

(2) An arc formed by electrons from 2, passes through a constricted region in 1 in order to reach the anode. Such a constricted region results in a high voltage drop adjacent to 2, so that positive ions striking 1 will do so with considerable energy. This large energy favors formation of a cathode spot.

The high arc drop resulting from the arc burning in constricted region 1a causes the cathode spot to move

rapidly out of the constricted region. This rapid motion of the spot prevents excessive local heating, and adds to the life of the cathode. It is also possible, if desired, to produce additional cathode spot motion by suitable arrangement of a magnetic field in a manner well known to the art. Such a method is often used to produce continued motion of a cathode spot, as exemplified in the Journal Applied Physics of March, 1950, page 193.

Although a 3-element tube, only, is shown in the figure, my excited spot cathode can be applied to any type of gaseous discharge tube, and it is not my intention to limit its application to the type shown.

I claim:

1. A gaseous discharge tube of the spot excited cathode type comprising an envelope, a cathode and an anode in said envelope, said cathode being in the form of a hollow member having an opening directed toward said anode, said hollow member being formed of an intimate mixture of a metallic refractory conducting material and an insulating material, a thermionic element electrically connected to the interior surface of said hollow member and to an external lead on said envelope, and external leads on said envelope to said anode and cathode respectively.

2. The invention recited in claim 1, wherein said cathode insulating material is thoria.

3. The invention recited in claim 1, wherein said refractory conducting material is tungsten.

4. The invention recited in claim 3, wherein said hollow member is in the form of a cylinder.

5. The invention recited in claim 4, and a control grid located between said cathode and anode.

6. A gaseous discharge tube of the spot excited cathode type comprising an envelope, a cathode and an anode in said envelope, said cathode including a hollow, cylindrical member formed of a mixture of a metallic conducting, refractory material and of an insulating material of the group consisting of tungsten and thoria, thorium-molybdenum and thorium-rhenium, a thermionic element connected to said cylindrical member at the inner surface thereof, and external leads connected to said cathode, said anode and said thermionic element through said envelope.

7. The gaseous discharge tube according to claim 6 further comprising at least one control grid in said envelope intermediate said cathode and said anode, and an external lead connected thereto through said envelope.

8. In a gaseous discharge tube of the spot excited cathode type, a cathode consisting of a hollow, cylindrical member formed of a mixture of a metallic, refractory material and of an insulating material of the group consisting of tungsten and thoria, thorium-molybdenum and thorium-rhenium, and of a thermionic element connected to the inner surface of said hollow cylinder, said hollow cylinder being open at both ends.

9. The apparatus according to claim 8 wherein said metallic refractory material is tungsten.

10. The apparatus of claim 9 wherein said mixture is formed in ratio of 3 parts of said refractory material to 1 part of said insulating material.

11. A gaseous discharge tube of the spot excited cathode type comprising an envelope and at least a cathode and an anode in said envelope, said cathode consisting only of a hollow cylindrical member formed of an intimate mixture of a refractory, conducting material of tungsten and of an insulating material of thoria, said hollow cylindrical member being open in the direction of said anode, a thermionic element connected to said cathode at the inner surface thereof and leads connected to said element to pass a current therethrough.

12. A gaseous discharge tube of the spot excited cathode type comprising an envelope and at least a cathode and an anode in said envelope, said cathode including a hollow cylindrical member formed of an intimate mixture of a refractory, conducting material of tungsten and of an insulating material of thoria, said hollow cylindrical member having its axis substantially directed toward the anode, a thermionic element connected to said cathode at the inner surface thereof and leads connected to said element to pass a current therethrough.

13. A spot excited cathode for a gaseous discharge tube comprising a hollow cylinder of sintered tungsten and thoria, a thermionic element forming a minor portion of the said cylinder and means to pass a current through said thermionic element.

14. A gaseous discharge tube of the spot excited cathode type comprising an envelope and at least a cathode and an anode in said envelope, said cathode comprising a hollow cylinder formed of an intimate mixture of tungsten and thoria, a thermionic element forming a minor portion of said cylinder, and leads connected to said element to pass an electric current therethrough, said hollow cylinder having its axis substantially directed toward the said anode.

15. A gaseous discharge tube of the spot excited cathode type comprising an envelope and at least a cathode and an anode in said envelope, said cathode comprising a hollow cylinder formed of an intimate mixture of tungsten and thoria in proportions of about 3 parts tungsten to one part thoria, a thermionic element connected to said cylinder and forming a minor portion of the said cathode, and means to pass a current through said thermionic element, the said hollow cylinder having its axis substantially directed toward the said anode.

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