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CATHODE CONSTRUCTION

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Fig. 1

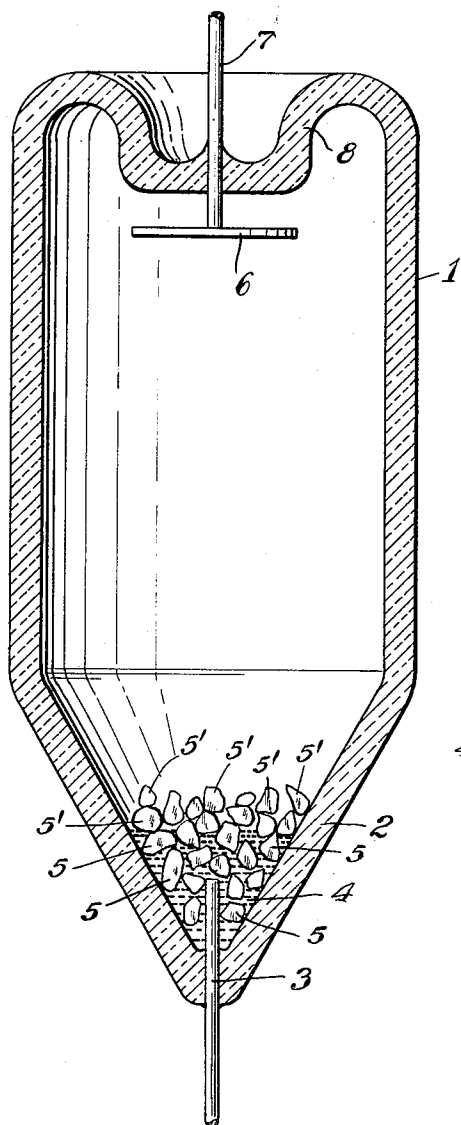
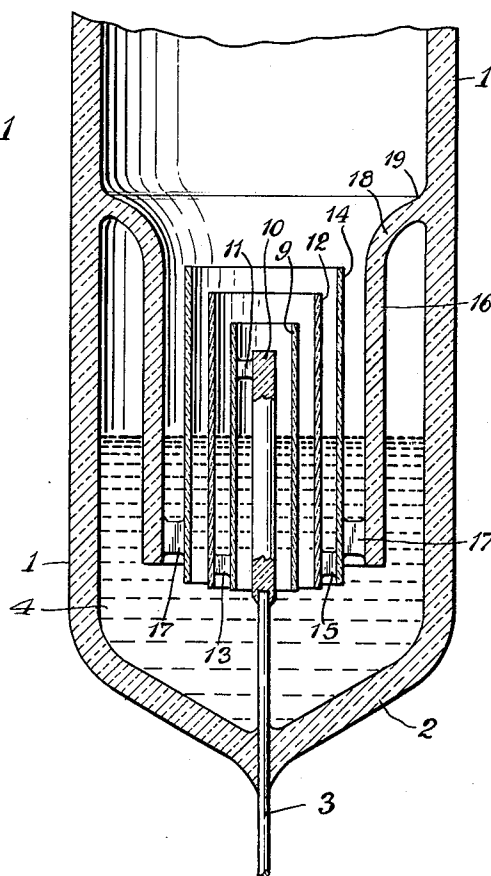


Fig. 2



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CATHODE CONSTRUCTION

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13 Claims. (Cl. 313-173)

1 This invention relates to the construction of a cathode and has for one object to provide in connection with a cathode means for stabilizing an arc which is formed or is to be formed on the cathode and between it and an anode. In general, the device comprises a sealed envelope of transparent or translucent material from which the air has been substantially exhausted.

There are present within the envelope an anode and a cathode which are separated from each other. Electrical connections are made through the envelope to the anode and the cathode. The cathode is preferably formed of metal which is in liquid or substantially liquid form at operating temperatures. It is at present known to construct tubes and anodes and cathodes as stated.

Arcs of the general type described have been known for several decades, and they have numerous advantages for use at currents of several amperes. Chief among these is relatively small dissipation of energy as heat and a correspondingly high efficiency. There are, however, disadvantages which have seriously limited their use. In the first place, they generally fail to operate reliably on low currents. Once extinguished, they are difficult to start unless auxiliary starting equipment is provided. In consequence of this situation, arcs operating on currents less than an ampere have usually been provided with cathodes emitting electrons through thermionic emission. The disadvantages attending this choice are: (a) relatively low efficiency, (b) severe current limitation, and (c) relatively short life of the equipment, which if current limitations are exceeded momentarily is catastrophically reduced.

There have, of course, been corresponding difficulties associated with pool type cathodes. If, as when the cathode pool consists of alkali metal, the cathode spot anchors in the vicinity of the junction between the pool and the envelope, the arc is stabilized and the current may be reduced to a low value, about 100 milliamperes, without going out. In this case, however, the useful life of the arc tube itself is reduced because the envelope soon cracks as a result of the heating of the wall by the cathode spot or by chemical reaction between the alkali and the glass in this region or by a combination of both. When, as in the case of mercury, the pool does not wet the glass envelope, there are no thin films of the metal spreading over the surfaces of materials of low thermal conductivity, the spot does not attach itself at any of these surfaces but wanders at random over the entire surface of the mercury pool. In such a case, if the area of the pool is

2 not extremely small, a relatively large current (several amperes) is required to maintain the cathode spot. If the current is reduced below a critical value, the arc soon goes out. Once extinguished, such an arc is not readily re-established by means of a glow to arc transition.

In this invention means are provided for eliminating or very greatly reducing the disadvantages of pool-type cathodes without interfering in any way with their advantages in terms of efficiency.

Reduction of thermal conductivity in the vicinity of the cathode spot makes it possible to maintain the cathode spot on lower currents.

One of the objects of the invention is to provide places away from the envelope at which the thermal conductivity is sufficiently reduced to provide for the anchoring of the spot without endangering the envelope by the heat dissipated at the spot.

This condition of reduced thermal conductivity at localized spots is observed to make possible the glow to arc transition under conditions of voltage and current at which it would otherwise be impossible to accomplish the transition. In such devices, using a mercury cathode, we have been able to start the arc by the application of voltage directly without any apparent glow preceding the arc. The potential difference required was just less than 1000 volts and the current at the time the arc struck was about 400 milliamperes. This current was reduced to less than 100 milliamperes before the arc went out.

To make proper use of the principle set forth in this disclosure it is important to be able to control surface conditions in such a way that the wetting of certain surfaces by the metal of the cathode pool is prevented while the wetting of other surfaces at the same time is made very effective and complete. The alkalis wet clean glass; so this presents no considerable difficulty. On the other hand, certain coatings used commercially prevent the alkalis from attacking glass, and these may be used to increase the life of the envelope. Mercury fails to wet clean glass, and for pure mercury cathode pools no special treatment of the envelope is necessary. If the ceramic structure introduced in the cathode pool breaks the mercury into well defined paths of electrical conductivity of small diameter, special treatment of the ceramic surface is relatively unimportant. It is sometimes advantageous to treat the surface to make it wettable by the mercury. This can be accomplished by putting onto the ceramic a thin film of a material which mercury will wet.

Another object of the present invention is, therefore, to accelerate this transition.

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Other objects will appear from time to time throughout the specification and claims.

The invention is illustrated more or less diagrammatically in the accompanying drawings wherein Figure I is a section through one form of the tube or device in which the construction of the present invention, particularly as it relates to the cathode, is embodied.

Figure II is a sectional view of a modified form in which the ceramic or other material positioned within the cathode pool is regularly shaped.

Like parts are designated by like characters throughout.

In the particular form shown, the invention comprises a tube, bulb or envelope 1. This may be formed of glass, quartz or other transparent or translucent material. As shown, it may conveniently be formed with a tapered or reduced portion 2 within which a cathode pool is received. A conductive connecting member 3 extends through the wall of the envelope 1 in the reduced portion 2 and extends into the pool of metal 4 to establish an electrical connection between the cathode formed by this pool or embodying this pool and source of electrical current outside the envelope 1. The pool 4 is formed of metal which is liquid or substantially liquid at operating temperatures. This may be caesium or potassium or any alkali metal. Under certain conditions there may be combined with the alkali metal a quantity of mercury. The invention is therefore not limited particularly to the use of alkali metal alone or in combination with other materials. Mercury alone might be used.

Mixed with or positioned partially within the metal pool 4 is a quantity of ceramic or other non-conductive or semi-conductive material. As shown in the figure this material may comprise broken or crushed pieces 5 of glass. These pieces as shown are, some of them, in contact with the envelope 1, particularly the reduced portion 2 of that envelope. Some of the pieces 5 extend to and outwardly above the exposed surface of the metal pool 4. These pieces are indicated particularly at 5'. The precise number and arrangement of the parts or pieces of ceramic material is unimportant. Normally there will be a number of such pieces and they will extend from a point below the surface of the metal pool to a point above the exposed surface of the pool. Possibly only a single piece of the material 5 might be sufficient so long as it is of such size and other physical properties as to extend from below the exposed surface of the pool 4 to a point at least slightly above that surface. The precise distance of the extension of the piece 5 above the surface of the pool is immaterial. The piece 5 or at least one piece 5 must break the surface of the pool so that it is exposed and can serve as a focus for the location of that part of the arc which is established on the cathode. If several pieces 5 or 5' are exposed, the operation will be satisfactory. Ordinarily, satisfactory operation is possible if only a single piece is exposed.

It is important to recognize that the ceramic or other non-conductive or semi-conductive material such as the parts 5 and 5' does not float upon the surface of the metal. It extends below the surface. In the case of a pool formed of an alkali metal, the parts 5 may be of glass or other ceramic material. They are of such specific gravity that they sink. Therefore, they will have to be present within the cathode in sufficient quantity to extend from the envelope to and at

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least slightly above the exposed surface of the alkali liquid cathode pool.

If mercury is to be used for the cathode pool instead of an alkali metal such as, for example, potassium or caesium, glass or other ceramic material would float upon the exposed surface of the mercury pool. This is undesirable and if mercury is used the piece or pieces of ceramic or other material used will be secured to the envelope so that instead of floating upon the exposed surface of the electrode, they are anchored to the envelope and extend from below the exposed surface of the pool to and through that surface.

One convenient method of making the device of the invention is to form the glass envelope 1 suitably shaped, for example, by the restriction 2 and provided with the entering metal wire 3 which is sealed into the reduced portion 2. Broken or fragmentary glass particles 5 are then put into the reduced portion 2 in such quantity as to fill the portion 2 to the desired degree. Thereafter, the metal which forms the metallic cathode pool 4 is introduced. If it is an alkali metal, the particles or pieces 5 need not be fastened in place and the alkali metal will merely fill the spaces between the pieces 5. The alkali metal is put in in such quantity as to bring its level to a point just below the tops or upper portions 5' of the quantity of glass particles 5 which has already been put into the restriction or shaped portion 2.

Thus far alkali metal cathode pools have been primarily referred to. The same general steps can be used to produce the construction of the invention broadly even if mercury pools are used or if pools formed of a mixture of mercury and alkali metals be used. As above suggested, because of the greater density of mercury as compared to caesium, for example, the glass or other ceramic particles would float. For that reason they must be anchored to the envelope. They must be secured to some point below the exposed surface of the cathode pool. Instead of a group or quantity of disconnected ceramic pieces, such as the pieces 5, a porous matrix or other regularly formed member might be used and this member would be secured to the envelope so that it would not float no matter what the particular metal of the cathode might be. Such a member might be of any desired shape and would normally provide sufficient open spaces to permit proper electrical connection between the cathode pool and the wire 3, and particularly between the wire and the surface of the cathode pool. It is important that the material, whether it be separate pieces such as the pieces 5, or a single formed member or a matrix or what not, shall be of such dimension and shape that it does not prevent adequate electrical connection between the surface of the cathode metal pool 4 and the wire 3.

Whatever the details of the cathode, whether the metal be mercury, an alkali metal, or a mixture of the two, the cathode will be formed of a metal which is liquid at operating temperatures and one or more members will be positioned in the metal pool in such manner as to break the exposed surface of that pool and preferably to extend somewhat above that surface into the interior of the envelope 1.

In addition to the cathode, an anode 6 is provided. This anode may conveniently be carried to a lead-in wire 7 which extends through and is sealed with respect to the portion 2 which

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closes the envelope 1. The invention is not limited to the particular type of anode nor to the shape or proportions of the envelope.

In the modified form of Figure II, the ceramic or other material which is positioned within the cathode pool is regularly shaped. As shown, the envelope 1 is identical with the envelope of the earlier figure; the lead-in wire 3 is identical and a metal pool 4 is present in the reduced portion 2 of the envelope 1. This metal pool is formed of metal which is liquid at operating temperatures. Instead of the particles or pieces 5 positioned within the cathode pool as shown in Figure I, there is provided a group of regularly formed concentric tubular members which are positioned preferably concentrically with respect to each other and to the envelope 1. Thus an inner tube 9 is supported from a rod-like member 10 formed as an extension of and supported upon the lead-in wire 3. The tube 9 is supported from the member 10 by one or more connections 11. A second tube 12 is supported from the tube 9 by a connection 13. A third tube 14 is supported from the tube 12 by a connection 15. An outer tubular member 16 is connected to the tube 14 by one or more connections 17. The outer tubular member 16 is preferably flared outwardly adjacent its upper end as at 18 and is sealed or otherwise tightly secured to the envelope 1 as at 19. The total tubular structure is thus supported in part from the member 16 by its connection to the envelope 1 and in part from the member 10 by its connection to the lead-in wire 3. The total construction of the rod 10 and the tubular members surrounding it comprises means for establishing a plurality of annular concentric spaces into which the metal 4 of the cathode pool flows or extends as shown in Figure I. Each of the tubes as well as the rod 10 extends through the surface of the pool and breaks that surface.

The invention is not limited to the particular dimensions of the parts shown. Actually the pieces 5 in practical use will probably be not more than one-fifth the size shown in Figure I. Their size is exaggerated in that figure for purposes of clarity. Where in the specification and claims an "anode" is referred to, it is to be understood that one or more anodes may be used and the expression quoted is not a limiting expression and does not limit the combination to the presence of a single anode. Ordinarily, or at least very frequently, there will be a plurality of anodes present in a given tube or envelope and the invention is to be understood as not being limited to any particular number of anodes. Reference has been made to the transition from the "glow" to the arc. This transition may sometimes be so rapid that it may not be observed.

In the specification it is stated that the metals of the cathode may "wet" the glass. This word is used as meaning that if a metal spreads out on a surface when free to do so, it may be considered as wetting that surface.

Caesium generally wets glass. For some purposes it is desirable to prevent that wetting, particularly to avoid destruction of the glass envelope. A coating for glass to protect it from caesium and other alkali metals is now available on the market. Its precise chemical nature is not disclosed. It is available under the trade name "K-Coated" or "K-Coating." Glass presently treated with this material is available for use. This material is cited as an example of a coating for glass which would prevent its wetting by alkali metals. Mercury will ordinarily not

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wet a glass surface. It will however wet a glass surface which has been treated by the application of a thin film of clean tungsten. This may be applied by vaporizing the tungsten and causing it to condense upon and thereby to deposit a layer upon the glass. Glass so treated will be freely wetted by mercury. Another treatment which can be applied to glass to render it wettable by mercury, is that of applying a coating of gallium to the glass. The gallium itself will wet the glass and the mercury will thereupon wet the glass over the coating of gallium. These two treatments are mentioned to indicate that known methods and products exist for the treatment of glass to render it wettable by mercury.

Use and operation

In general when the device is to be used, it is connected into an electrical system by means of which the wires 3 and 7 are in contact with a source of electric current. That current will be such that it will produce first a glow and then an arc, the arc extending between the anode and the cathode. It is not necessary to describe starting devices and ballasts which may be used as desired. Such structures are well known and currently available on the market.

One of the advantages of the use of the present construction is that the ignition of the arc is accelerated so that the arc is formed rapidly, more rapidly than with devices at present available. The arc once formed is also stabilized and tends quite definitely to remain in a stable position with respect to that portion of the cathode pool. Arcs having cathodes formed in the manner above described operate well at very low currents. For example, an arc has operated satisfactorily with caesium as the cathode pool metal, operating this in caesium vapor at 100 ma.

Where in the specification and claims it is stated that the ceramic or other particles and pieces extend above the surface or break the exposed surface of the cathode pool, it is to be understood that there might, in fact, remain above the uppermost portion of the parts 5, for example, and 5', a thin film of the metal which forms the cathode pool. In actual practice, in commercial manufacture, the tolerances necessary to preserve the level so exactly and to preserve the location of the ceramic or other pieces so exactly as to preserve a thin film over the uppermost portion or portions of the ceramic pieces is impossible. For that reason, in normal commercial manufacture almost invariably the production will be made that the members 5 and 5' and their equivalents extend sufficiently upwardly to break the surface of and to be in part exposed above the cathode metal pool, and where in the claims it is stated that these members do extend above the surface, it is to be understood that this language would include also a construction in which a very thin or minute film of the cathode metal overlies the uppermost portion or portions of the parts 5.

We claim:

1. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, and a quantity of separated pieces of ceramic material in said envelope positioned within said pool extending below and projecting above the upper surface of said pool.

2. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, said metal pool comprising an alkali metal, and a quantity of separate pieces of ceramic material in said envelope positioned within said pool extending below and projecting above the upper surface of said pool.

3. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, and a quantity of separated ceramic material within said pool partially below and partially above the upper surface of said pool.

4. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, said metal pool comprising an alkali metal, and a quantity of separated ceramic material within said pool partially below and partially above the upper surface of said pool.

5. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, and a quantity of separated parts of a semi-conductor within said pool and extending above its upper surface.

6. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, and means for breaking the surface of said pool comprising separate ceramic members extending from a point below the surface of said pool to a point above said surface.

7. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, and means providing a plurality of separate areas of non-conductive material extending beyond the surface of said pool, said means comprising ceramic material extending from within the mass of said pool outwardly through its surface.

8. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, said metal pool comprising an alkali metal, and means providing a plurality of separate areas of non-conductive material extending beyond the surface of said pool, said means comprising ceramic material extending from within the mass of said pool outwardly through its surface.

9. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and

an anode positioned within said envelope and spaced away from said cathode, said metal pool comprising caesium, and means providing a plurality of separate areas of non-conductive material extending beyond the surface of said pool, said means comprising ceramic material extending from within the mass of said pool outwardly through its surface.

10. In combination, an airtight envelope substantially free from air, a pool of metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, said envelope being treated so that said cathode pool does not wet the part of the envelope with which it comes in contact, and means providing a plurality of separated areas of non-conductive material extending beyond the surface of said pool, said means comprising ceramic material so treated that the metal of the pool wets said ceramic material which extends from the mass of said pool outwardly through its surface.

11. In combination, an airtight envelope substantially free from air, a pool of alkali metal which is in liquid form at operating temperature in said envelope, said pool comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode, said envelope being treated so that said cathode pool does not wet the part of the envelope with which it comes in contact, and means providing a plurality of separate areas of non-conductive material extending beyond the surface of said pool, said means comprising ceramic material extending from within the mass of said pool outwardly through its surface.

12. In combination, an airtight envelope substantially free from air, a pool of mercury comprising a cathode, and anodes positioned within said envelope and spaced away from said cathode and means providing a plurality of separate areas of non-conductive material extending beyond the surface of said pool, said means comprising ceramic material treated so that the mercury of the pool wets said ceramic material which extends from the mass of said pool outwardly through its surface.

13. In combination, an airtight envelope substantially free from air, a pool of mercury comprising a cathode, and an anode positioned within said envelope and spaced away from said cathode and means providing a plurality of separate areas of non-conductive material extending beyond the surface of said pool, said means comprising a connected structure of ceramic material treated so that the mercury of the pool wets the surface of said ceramic material which is anchored in place by a mechanical connection to said envelope and which ceramic structure is so positioned that parts of it lie below the surface of the mercury and so that some parts extend from the mass of said pool outwardly through its surface.

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