May 9, 1950 B. P. DE LANY ET AL 2,507,434

POOL TYPE CATHODE WITH MEANS FOR ACCELERATING ARC FORMATION

Filed July 14, 1948 2 Sheets-Sheet 1

Fig. 1

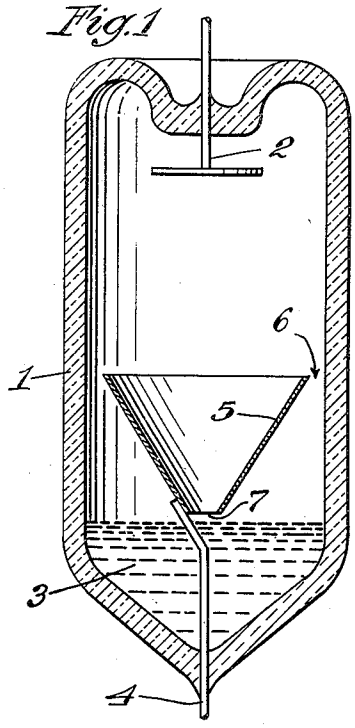


Fig. 2

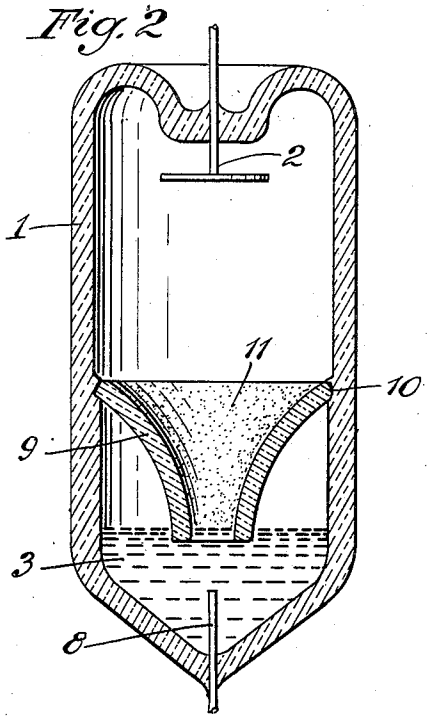


Fig. 3

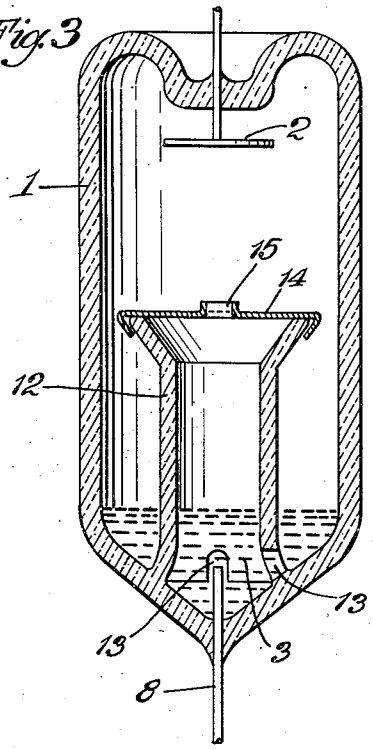
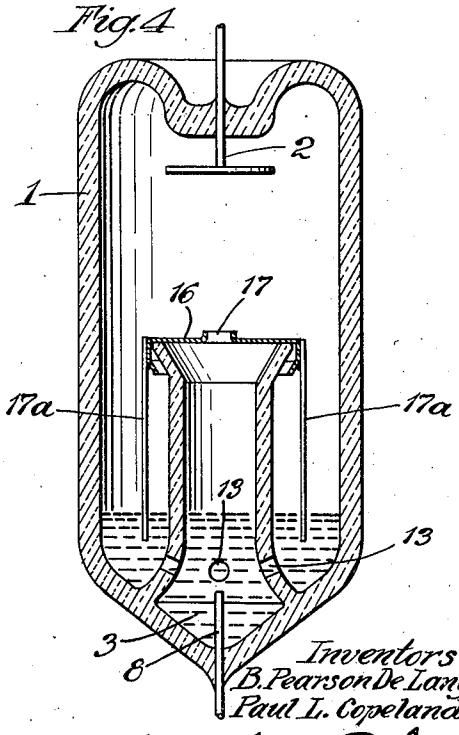


Fig. 4



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Fig. 5

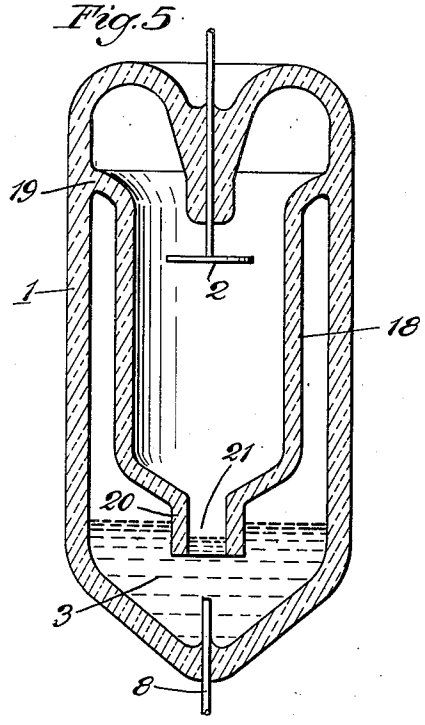


Fig. 6

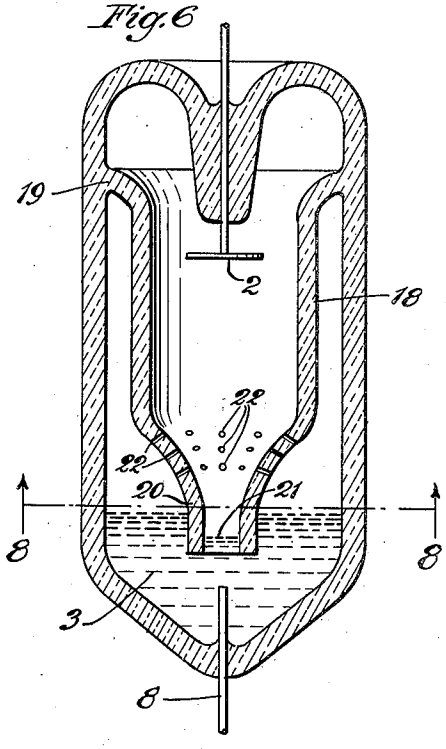


Fig. 7

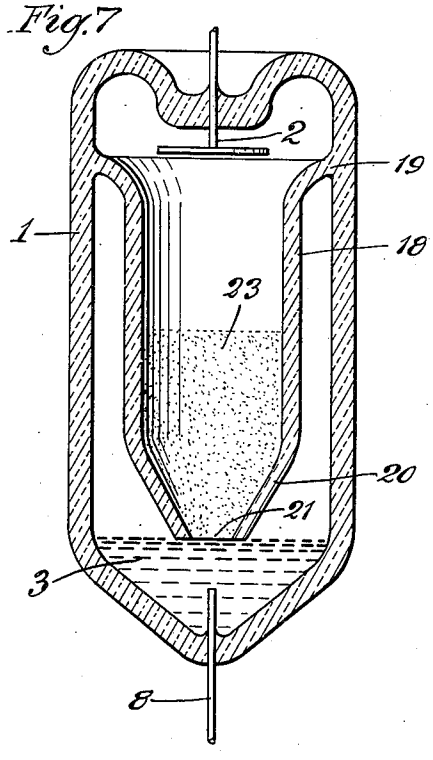
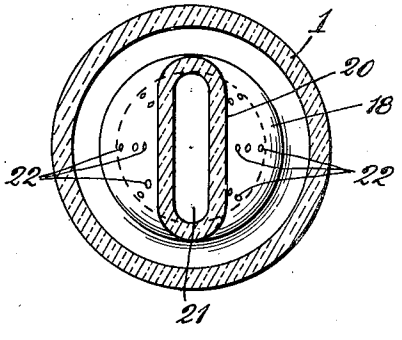


Fig. 8



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POOL TYPE CATHODE WITH MEANS FOR ACCELERATING ARC FORMATION

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14 Claims. (Cl. 250—27.5)

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This invention relates to a cathode for mercury arcs and has for one object to provide a cold cathode electrical rectifier. In the particular form here shown it may be described as a mercury pool type, cold cathode.

It has for another object to provide a cathode of the type indicated in which the discharge is initiated easily and may be maintained simply in trouble free operation.

Another object is to provide a cold cathode means for stabilizing the arc and for facilitating the transition from initial glow to effective arc.

Another object is to provide in a cold cathode means for securing arc operation at low temperatures and without the use of auxiliary starting devices.

It is recognized that mercury arcs have been extensively used. In such devices in the past, however, substantial and relatively expensive auxiliary equipment has been required for starting the arc, and this fact has tended to limit the use of such devices. In general it has been considered that pool type cathodes are justified only in the case of large installations in which the cost and bulk are not prohibitive. However, the cost and bulk of such auxiliary equipment has made the use of pool type cold cathodes prohibitively expensive in connection with small tubes. It is, therefore, one of the objects of the present invention to provide a pool type cold cathode which eliminates the necessity of auxiliary equipment and which is suitable for small installations and which at the same time gives rapid arc initiation and satisfactory operation over long periods.

Another object is to provide a cathode of the type indicated which will not be damaged or put out of operation by overloads, whether they be instantaneous, as will often occur, or long continued.

The cathodes of the present invention are illustrated in the drawings and described herein. Before describing the drawings, the general theory of operation and construction will be outlined.

Generally the cathode comprises a pool of mercury within a glass tube or envelope, and means are provided in one form or another for limiting the area of the mercury pool which is exposed. This may comprise a constriction in the wall of the tube or other envelope within which the arc occurs. By this means the cathode pool area exposed to the discharge is limited to something less than the total area of the pool. With this is combined in the tube or envelope an auxiliary cathode which in general consists of a conductor in the form of a solid or relatively large area.

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In another form the device of this invention comprises a cathode pool of large area which is divided by a constriction—preferably slot shaped. This constriction produces an inner area of the pool which is relatively small and an outer area which is relatively large. Relatively small openings such as "pinholes" may be formed in the constricting tube or other member.

The device generally comprises in all forms a tube or envelope formed of insulating material such as glass. Within this is placed a pool of mercury and constricting means are provided which are effective to limit the cathode pool are exposed to the discharge. By means of this construction an effective mercury arc is provided which operates satisfactorily without auxiliary starting equipment, which accomplishes a rapid initiation of the arc and continued satisfactory arc operation. The source of electrons in all the forms of the device of this invention is a small luminous spot on the surface of the mercury pool. This spot covers only a small portion of the area of the pools.

It is unnecessary here to describe or explore the various theories concerning the exact mechanism or process for the extraction of electrons from this spot. It is sufficient to state that arcs are characterized by high current densities at the cathode and that devices made according to the present invention operate satisfactorily as arcs. A theory of operation of the devices of this invention is that the discharge from the anode is channeled or directed and that the current density at the cathode is increased, even before the spot forms, by the channeling. Because the current density is high at the cathode as a result of channeling, the formation of a spot is facilitated. After the spot is formed a limitation of the effective area by this channeling tends to maintain the existence of the spot. By "effective area" is meant the effective area of the cathode pool exposed through the opening in the restriction. This area is substantially the projection of that opening upon the exposed surface of the cathode pool. The luminous spot is developed and the arc initiated promptly and satisfactorily.

Generally it may be said that there is at present no complete agreement as to the theory of electron extraction in cathodes of the pool type. However, in the devices of this application, by condensing the discharge from the mercury pool by means of a constriction, it has been possible to facilitate the transition from glow to arc and in one typical case to maintain a true arc with a cathode spot for a current as low as 25 milliamperes.

An auxiliary metal cathode may be used in addition to the mercury pool cathode. This cathode may be in the form of a wire or a metallic cone or a metallic tube or thimble. It may also comprise a metallic film on the wall of an insulating member, which insulating member accomplishes the constriction above referred to.

Mercury has been spoken of above as a suitable metal for forming the cathode pool. Another suitable metal is cesium, which is a metal liquid at room temperatures which emits electrons freely and which is used in certain types of gas discharge tubes. Its charcteristic radiation differs from that of mercury. A choice between the two metals would involve a consideration of the relative cost of the metals and of the type of radiation desired or useful in the particular use to which the cathode is to be applied.

Among the advantages inherent in the structure of this invention are the following: The spot is formed more rapidly. The relatively large total cathode area makes it easy to establish a glow. The relatively small pool area exposed to the discharge facilitates the glow-to-arc transition. Once the arc has been formed the spot remains stable—that is, it is maintained easily and does not tend to disappear. It might be said that the restriction "channels" the electric current from the anode to the cathode.

This invention is illustrated more or less diagrammatically in the accompanying drawings, wherein:

Figure 1 is a longitudinal section through a tube embodying the invention;

Figures 2 to 7, inclusive, are similar views illustrating modified forms; and

Figure 8 is a section taken at line 8—8 of Figure 6.

Like parts are indicated by like characters throughout the specification and the drawings.

Generally the cathode of this invention is embodied in a tube, bulb or other envelope which is gastight and from which the air has been removed and into which a gas or a vapor may have been inserted. A metal anode which may be of nickel, tantalum or any other suitable anode material is positioned within the envelope, and a cathode formed of mercury or cesium is also positioned within the envelope. The anode and cathode are connected through the envelope to a source of electrical current outside of the envelope. A restriction of some sort is positioned between the anode and the cathode. With these general features in mind, the seven forms illustrated herewith will be described.

As shown in Figure 1, 1 is the envelope. In this form it may be a glass tube. An anode 2 is positioned within the envelope and a cathode pool 3 of mercury lies in the bottom of the envelope or tube 1. A lead-in wire 4 of tungsten or other suitable material passes through the wall of the envelope and through the pool of mercury. A cone 5 of tantalum is positioned within the envelope and above the mercury and may be supported by the member 4, as shown. The cone may at its upper edges be spaced away from the envelope, providing a clearance 6, or it may be in contact with the envelope. At its lower end the cone is open, perforated or truncated, as at 7.

In the form of Figure 2 the envelope 1, the anode 2 and the mercury pool 3 are the same as shown in Figure 1. The lead-in wire 8 extends into the envelope only enough to be in full contact with the cathode pool 3. It may

be of tungsten or other suitable material. A funnel-like member 9 of glass or comparable material is positioned within the envelope and is sealed at its edges to the envelope as at 10. On the inner surface of the funnel 9 is positioned or formed a film 11 of some suitable metal or semi-conductor, such as tungsten or silicon. The open bottom end of the funnel extends downwardly and contacts the upper surface of the cathode pool 3.

Throughout the specification when the cathode pool is referred to as being formed of mercury, it is to be understood that this word is used not exclusively, but is to include other materials which remain liquid at normal operating temperatures and thus to include also cesium. In all of the several forms of the device shown the cathode pool might be formed of cesium instead of mercury.

In Figure 3 the envelope 1, the anode 2, the cathode pool 3 and the lead-in wire 8 are as shown in Figure 2. A glass tube 12 is positioned within the envelope and its ends may be flared as shown. They may also be straight and unflared. At its lower end the glass tube 12 is fastened to the wall of the envelope 1, but one or more openings 13 are left in the tube 12 and within the pool 3 so that the material of the pool may circulate through such openings. At its upper end the tube 12 is closed by a perforated metallic member 14. As shown the member may be of copper. If desired a small tubular portion 15 defines the perforation through the copper member 14.

In the form of Figure 4 the envelope 1, the anode 2, the pool 3, the lead-in wire 8 and the tube 12 with its openings or perforations 13 are all the same as shown in Figure 3. The upper end of the tube is partially closed by a metallic member 16 which may be perforated, as at 17. Secured to the metallic member 16 and depending downwardly from it and into the pool 3 is a plurality of metal wires 17a. These may be of tungsten or other suitable material.

As shown in Figure 5 the envelope 1, the cathode 2, the pool 3 and the lead-in wire 8 are the same as shown in several previous figures. A glass tube 18 is positioned within the envelope and sealed to it about its upper edges, as at 19. The tube is constricted and flattened at its lower end, as at 20, to form a slot-like opening 21. The lower end 20 extends slightly below the upper surface of the pool 3 of the cathode.

The form shown in Figure 6 is the same as that shown in Figure 5, with one exception. The tube 18, which is flattened, is provided with a plurality of small holes 22, of the order of pin holes. These may be arranged regularly or irregularly. The forms of Figures 5 and 6 are identical except for the pinholes.

The form of Figure 7 is generally the same as that of Figure 5, and most of the reference numerals are the same. The form of Figure 7 differs from the form of Figure 5 by the fact that a portion at least of the inner surface of the flattened tube 18 is provided with a film 23 of tungsten or equivalent material.

The use and operation of the invention in any of the forms shown is as follows:

A tube with the cathode of the present construction is inserted in a system where it may be useful. Cathodes of the present design are not limited to the use in tubes for any specific purpose. They may be used in rectifier tubes, lighting tubes or any other tubes in which it is de-

sired to use a cold cathode which will start readily without auxiliary mechanism and with low current at relatively low potentials.

With the tube embodying the present cathode installed in any such system, the anode 2 and the cathode pool 3 are connected to sources of current and when the potential is sufficiently high, a spot is formed within the uncovered area of the cathode pool. Usually this spot will be formed at a point within the projected area of the open space within the restriction. For example, it will be within the open space of the funnel 9 of Figure 2.

In the forms of Figures 5, 6 and 7 it will normally be within the open space formed by the flattened tube 18. In the form of Figure 6 it may also form outside this area through one or more of the pinholes 22. Generally a spot is formed, and almost immediately a regular complete arc is developed, and the device is then in full useful operation, and because of the constriction the arc remains stable and continues until the device is disconnected from the source of current, or the electromotive force falls below a critical value.

The pinholes 22 are effective only at relatively high gas or vapor pressure, of the order of ½ millimeter to 5 millimeters of mercury. When the pressure is such as to make the pinholes 22 effective, the discharge passes through one or another of the pinholes and continues to operate through the hole with high stability, the spot occurring where the discharge through the hole strikes the mercury. The "streamer" of the discharge remains concentrated rather than spreads after it passes through the pinhole.

We claim:

1. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-shaped member being in contact with said envelope and being provided with conductive surface means.

2. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-like member being formed of insulating material and sealed at its upper end to said envelope.

3. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away

from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-like member being formed of insulating material and sealed at its upper end to said envelope, and metallic film positioned upon the inner surface of said funnel-like member.

4. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a tubular member formed of insulating material positioned within said envelope and extending at one end into said pool, there being a metallic partition positioned across the free end of said tubular member, said metallic partition being perforated.

5. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a tubular member formed of insulating material positioned within said envelope and extending at one end into said pool, there being a metallic partition positioned across the free end of said tubular member, said metallic partition being perforated, said tube being flared at its upper and lower ends.

6. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a tubular member formed of insulating material positioned within said envelope and extending at one end into said pool, there being a metallic partition positioned across the free end of said tubular member, said metallic partition being perforated, and metallic wire-like members extending from said partition to said pool.

7. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted

open bottom, said top extending in the direction of said anode, said funnel-like member being flattened at that portion which is in contact with the pool.

8. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-like member being flattened at that portion which is in contact with the pool and being provided with a metallic film on its inner face.

9. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-like member being flattened at that portion which is in contact with the pool, and a plurality of relatively minute perforations in said flattened member adjacent the surface of said pool.

10. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-like member being flattened at that portion which is in contact with the pool and sealed to said envelope adjacent its upper end.

11. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a generally funnel-shaped member with a wide open top and a restricted open bottom, said top extending in the direction of said anode, said funnel-like member being formed of insulating material and sealed at its upper end to said envelope, and semi-conductive film positioned upon the inner surface of said funnel-like member.

12. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said concentrating means comprising a member at its upper end in contact with the envelope and at its lower end in continuous contact with the pool of metal and provided on its interior with a conductive surface.

13. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member, and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said concentrating means comprising a generally funnel-like member sealed at its upper and larger portion to the interior of said envelope and penetrating at its lower and narrower portion continuously into the liquid pool and provided on its inner face with a conductive surface in contact with the pool.

14. In combination, an airtight envelope formed of insulating material and substantially free from air, a pool of metal which is in liquid form at room temperature in said envelope, said pool comprising a cathode member and an anode positioned within said envelope and spaced away from said cathode, and electrical connections to said anode and said cathode, and means for concentrating the electron action of the anode upon a limited portion of the cathode pool area, said means comprising a tubular member formed of insulating material positioned within said envelope and extending at one end into contact with the metal of said pool, one end of said tubular member being sealed to the envelope and the opposite end of the tubular member being provided with a constricted opening in general alignment with the electron path between the anode and cathode, and electrically conducting means in contact with the metal of said pool surrounding and extending outwardly of said constricted opening.

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