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POINT ELECTRON SOURCE
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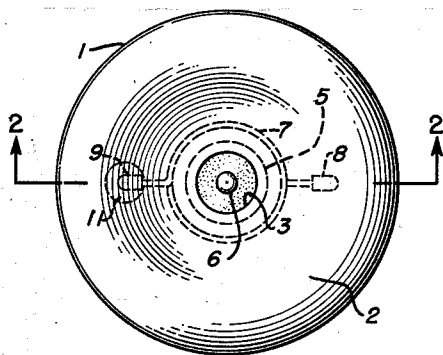


Fig. 1

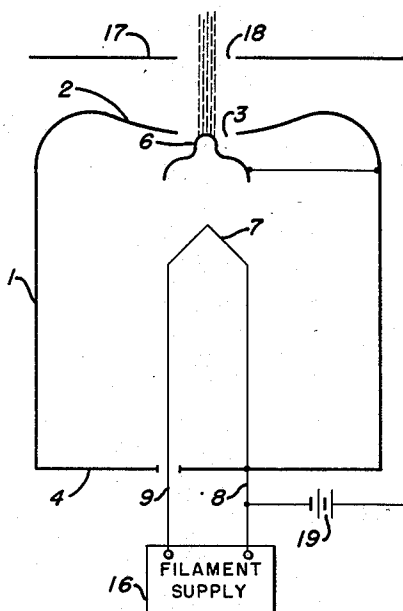


Fig. 3

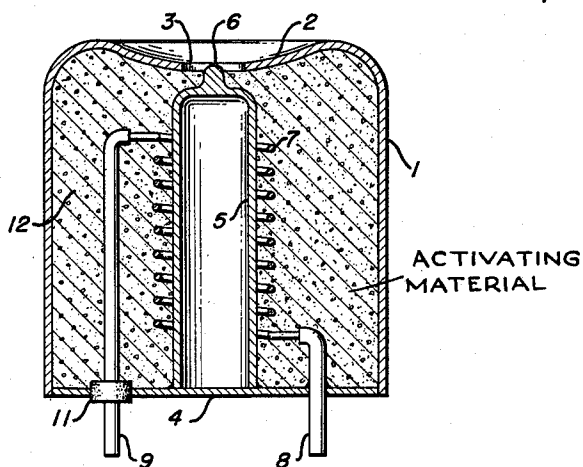


Fig. 2

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POINT ELECTRON SOURCE

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11 Claims. (Cl. 315—31)

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The present invention relates to an improvement in electron sources and is particularly concerned with improvements in so-called "point electron sources."

Many devices, such as, for example, cathode ray tubes, require a very narrow and concentrated beam of electrons and in the idealized condition such electrons are produced at a point. Electron sources suitable for such applications are commonly referred to as "point electron sources"; however, in practice it has been found that the electron emissive area of so-called "point electron sources" is necessarily appreciable, if an intense beam of electrons is to be produced. This situation is conventionally handled by the provision of an apertured shield adjacent the electron source whereby the electron beam cross section is reduced to the dimensions of the shield aperture. It will be appreciated that by this means a large amount of electrons emanating from the source are not usefully employed but are instead cut off by the shield structure with a consequently large source power drain for the resulting electron beam. The present invention overcomes the difficulties attendant conventional electron sources of this type by the provision of an electron source so closely approximating a true "point electron source" that no electron beam reducing means are required, as the source itself produces an intense electron beam of very small cross section.

It is an object of the present invention to provide an improved electron source having substantially a point of electron emission.

It is another object of the present invention to provide an improved electron source emanating electrons in a beam of small cross section.

It is another object of the present invention to provide an improved electron source having a continuously replaceable electron emission surface.

It is still another object of the present invention to provide an improved electron source focusing electrons emanating therefrom.

It is a further object of the present invention to provide an improved electron source having a continuously replaceable electron emission surface of very small area.

It is a still further object of the present invention to provide an improved method and means of producing high intensity electron emission from a very small area.

Further objects and advantages will be apparent from the following description taken together with the accompanying drawings wherein:

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Figure 1 is a plan view of an electron source embodying the principles of the present invention;

Fig. 2 is a cross sectional view of the source taken at line 2—2 of Fig. 1; and

Fig. 3 is a schematic illustration of the source of Figs. 1 and 2 showing associated electrical power supplies and connections.

Before discussing the illustrated embodiment of the invention it is to be noted that the present electron source is of the type sometimes called dispenser cathodes. This type of source or cathode is described in part in a patent to A. W. Hull et al., Patent No. 2,107,945, and some later developments thereof are described in Philips Technical Review, June 1950, pages 341 to 350. In principle this type of source or cathode contemplates the reduction of the work function of an electron emission surface by the provision of a continuously replaceable layer thereon of vaporized activating material. It was long ago discovered by Irving Langmuir and others in the field that the work function of the surface of certain metals is materially reduced when covered with a monoatomic layer of certain other materials, sometimes denominated as activators or activating materials. Although the exact mechanism of this phenomenon is in part incompletely understood there have been advanced logical explanations wanting only positive confirmation, and a wealth of data definitely establishes the fact that a monoatomic layer of activating material deposited upon certain surfaces materially reduces the work function and increases the electron emissivity. The present invention employs the dispenser principle in a particular manner to provide a new and improved electron source as will be seen from the following description.

Considering Figs. 1 and 2, it will be seen that there is provided an outer shell 1 which may have the form of a closed cylinder as shown. Shell 1 is provided at one end with a concave face 2 which has an aperture 3 formed there-through in the center thereof and has at the other end a closing wall 4. Shell 1, or at least the face 2 thereof, is formed of a material having poor electron emissive qualities as noted in more detail below and may comprise a metal such as tantalum. Internal to shell 1 and substantially coaxially therewith, there is disposed a core element 5 which has a small boss or raised portion 6 extending from one end thereof and which constitutes the electron emitter. Emitter 6 is formed with a smaller diameter than aper-

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ture 3 in face 2 and extends into aperture 3 with the extremity thereof in substantial alignment with the outer surface of face 2. As will be seen from Fig. 1, the source thus presents a concave face 2 having a centrally located aperture and an emitter 6 disposed concentrically within this aperture.

Core element 5 may be supported and maintained in position within shell 1 by any suitable means and in the illustrated embodiment, core element 5 extends the length of shell 1 and is secured to the end wall 4 thereof opposite face 2. Core element 5 may consist of a hollow cylinder as shown or alternatively may be formed as a solid billet and core element 5, or at least emitter 6 thereon, is formed of a material having high electron emissivity under certain circumstances, as noted below.

Heat is supplied to the electron source as by an internal filament 7 which may consist of a coil disposed substantially coaxially with shell 1 and core element 5 as shown. Mechanical support and electrical connections for filament 7 are provided by rigid terminal lugs 8 and 9 to which the opposite ends of filament 7 are connected. Terminal 8 extends through shell wall 4 and is rigidly connected thereto and terminal 9 extends through shell wall 4 in insulated relation thereto as by means of a lead through insulator 11 about terminal 9 and engaging wall 4. Terminals 8 and 9 provide external electrical connections by means of which filament 7 may be energized and shell 1 may be connected to a desired potential source.

Internal to shell 1 about core element 5 there is compacted an activating material 12 which volatilizes at temperatures readily realized by filament 7. Activating material 12 is preferably a powder or other readily compacted form and consists of material which in combination with the material of core 5, or at least emitter 6, forms an electron emissive surface of high emissivity. For example, emitter 6 may be formed of zirconium, titanium or molybdenum and activating material 12 of barium aluminate. Numerous combinations of materials are known which in combination, as described below, form surfaces of very high electron emissivity and thus the above example is not to be taken as limiting.

Considering the electrical connections of the illustrated electron source and referring to Fig. 3, it will be seen that a filament current supply 16 is connected across terminals 8 and 9 external to shell 1 and that filament 7 is connected across these terminals internal to shell 1. Thus filament 7 is energized by a current flowing there-through to produce heat within shell 1. Core 5 and emitter 6 thereon are electrically joined to shell 1 and thus emitter 6 is maintained at the same potential as the adjacent edges of aperture 3 in concave face 2. In order to remove electrons from the source there is provided an external electrode 17 at a distance from face 2 and having an aperture 18 therein in substantial alignment with aperture 3 in face 2. An electrostatic field is established between face 2 and electrode 17 by means of a potential source illustrated as battery 19 connected between electrode 17 and shell 1. Connection to shell 1 may be conveniently made at terminal 8 which, as noted above, electrically contacts shell 1.

Considering now the operation of the invention and referring to the above description as well as the drawings, it will be noted that fil-

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ament 7 is heated by current flowing there-through from heater supply 16 and that activating material 12 is in part volatilized thereby. As activating material 12 volatilizes it escapes from shell 1 through the aperture 3 in face 2 and there is a continuous flow of volatilized activating material 12 through aperture 3 over emitter 6. The surface formed by the thin layer of gaseous activating material 12 upon emitter 6 is highly electron emissive and the electrons emitted therefrom are attracted by the positive potential of electrode 17 so that copious quantities of electrons continuously emanate from the surface of the end of emitter 6. The face 2 of shell 1, being of a material such as tantalum, does not have a high electron emissivity when covered by a layer of activating material 12, and thus electrons are emitted only from the end of emitter 6 even though gaseous activating material flows in part over the surface of face 2. It will be seen therefore that the extent of electron emitting surface is readily controllable by controlling the extent of the end surface of emitter 6.

Further advantage lies in the concave configuration of face 2, for emitter 6 and face 2 are maintained at substantially the same potential with respect to electron attracting electrode 17. Thus the electrostatic field between face 2 and electrode 17 is converging away from face 2 and toward the axis of shell 1 or emitter 6. This electrostatic field tends to restrain electrons leaving the electron emissive surface from diverging and in fact exhibits a focusing action that constrains emitted electrons to travel in a beam of confined cross section. With the described electron source it is not necessary to collimate the emitted electron beam as it is already an intense beam of small cross section and the aperture 18 in electrode 17 serves only to allow electron passage and need not be maintained small for collimating purposes.

From the foregoing it is believed evident that the present invention provides an improved electron source having a very small high intensity electron emitting surface. In addition, the continuous flow of activating material 12 over emitter 6 insures a long life for the emission surface which is practically indestructible and everlasting, as only a very small flow of activating material is maintained and the size of the reservoir for activating material is practically unlimited. Also by the present invention an intense electron emission may be maintained from a very small area which is not possible with a directly heated cathode of conventional design for the danger of overheating and consequent damage to the emission surface is not present in this invention. Furthermore, all of the electrons emitted from the source are initially confined to a beam of appropriate diameter, and thus no power loss results from emitting large quantities of electrons that cannot be used, as is the case in conventional electron sources, and no problem of collimating the beam is encountered.

With regard to the electron emissive surface of the invention it is again noted that high emissivity is obtained by the provision of a monoatomic layer of activating material upon the surface of emitter 6. By the proper combination of activating materials and emitter metals the work function of the surface is reduced so that large scale emission is obtained at lower temperatures than would otherwise be possible. It will be seen that emitter 6 is heated by filament 7 to the

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proper temperature for maximum emission consistent with long-life, while face 2 remains at some lesser temperature by reason of the insulating effect of the activating material between filament 7 and face 2. As noted above, various combinations of emitting metals and activating materials are possible and thus these terms are not to be limited to the specifically illustrated materials but instead are taken to mean any materials which in the disclosed combination produce a surface having a low work function and consequent high electron emissivity.

While the present invention has been described with respect to a single preferred embodiment no limitation is meant thereby, for numerous modifications and variations are possible within the spirit and scope of the invention. For example, the configuration of shell 1 and the disposition and shape of core element 5 and filament 7 may be varied materially within the teaching of the invention and, of course, the concavity of face 2 is to be varied to achieve the degree of focusing desired. It is thus not intended to limit the present invention except by the terms of the following claims.

What is claimed is:

1. An improved electron source having a concave surface formed of poor electron emitting material, said concave surface having an aperture in the center thereof, an electron emitting element disposed within said aperture, an activating material about said electron emitting element, and means to continuously volatilize said activating material and cause said volatilized activating material to flow through said aperture over said electron emitting element whereby an electron emission surface is formed on said electron emitting element and defined by the edges of the aperture in said concave surface.

2. An improved electron source as claimed in claim 1 further characterized by an apertured electrode disposed adjacent to said concave surface and potential supply means connected therebetween to establish an electric field attracting electrons away from the electron emitting surface and focusing said emitted electrons into a sharply defined beam.

3. An improved electron source comprising an envelope having a face formed of a material having poor electron emission qualities, said face having an aperture in the center thereof, an activating material compacted within said envelope, a member disposed within the aperture in said envelope face, and heating means for continuously volatilizing said activating material which thereby flows through the aperture in the face of said envelope to form a continuously replaceable layer upon said member disposed in said aperture, said member being formed of a material coating with said layer of vaporized activating material thereon to form an electron emissive surface limited by the dimensions of said member in said aperture.

4. An improved electron source of the dispenser type having an apertured face formed of a first metal, an emitter element disposed within the aperture in said face and formed of a second metal, an activating material disposed adjacent said face, and a heater element heating said emitter element and said activating material to vaporize said activating material at a controlled rate whereby vaporized activating material flows through the aperture in said face and over said emitter element, said activating material com-

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prising a compound coacting with said emitter element to reduce the work function of the surface thereof and increasing the electron emissivity thereof.

5. An improved electron source of the dispenser type comprising an envelope having a face thereof formed of a first metal, said envelope face having an aperture therein, an emitter element formed of a second metal and disposed in the aperture in said envelope face, an activating material disposed within said envelope, and heating means heating said emitter element and said activating material to vaporize said activating material at a controlled rate whereby vaporized activating material flows across the surface of said emitter element exterior to said envelope, said first metal forming said envelope face being unaffected by vaporized activating material and said second metal of said emitter element having a reduced work function with a layer of activating material thereon whereby electron emission from said source is limited to the surface of said emitter element.

6. An improved electron source of the dispenser type comprising in combination a source face formed of a first metal and a second metal disposed about said first metal and defining an exposed surface thereon, an activating material, controlled heating means vaporizing said activating material, means directing a flow of vaporized activating material across said source face, and means heating said first metal, the work function of the surface of said first metal being lowered by the vaporized activating material and said second metal being relatively unaffected thereby whereby electron emission occurs only from said first metal.

7. An improved electron source as defined in claim 6 further defined by said source face being concave with said first metal being disposed at the maximum concavity thereof, an apertured electrode disposed adjacent said source face, and potential supply means connected between said electrode and said source face and establishing an electrostatic field therebetween whereby electrons are attracted from the electron emissive surface of said source face and said electrostatic field converges away from said source face to focus electrons attracted therefrom.

8. An improved electron source comprising a source face formed of tantalum metal, said source face being dish shaped and apertured at the maximum depression thereof, an emitter element disposed in said aperture and formed of a metal of the group comprising zirconium, titanium and molybdenum, an activating material disposed adjacent the convex side of said source face and comprising barium aluminate, and heating means adjacent said activating material and vaporizing said activating material at a controlled rate whereby vapor of said activating material flows through the aperture in said source face and over the surface of said emitter element to reduce the work function thereof, and said heating means heating said emitter element to a temperature of thermionic electron emission.

9. An improved electron source comprising an envelope having a concave face with an aperture therethrough at the maximum depression thereof, an emitting element within said envelope and extending into the aperture in said concave envelope face and having a surface substantially aligned with the exterior surface of said face, activating material compacted within said envelope about said emitter element, and a heating

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element within said envelope adjacent said emitter element for heating said emitter element and vaporizing said activating material whereby vaporized activating material flows through the aperture in said envelope face and over said emitter element surface, the exterior surface of said envelope face comprising a material having a large work function alone and when covered by said activating material and the surface of said emitting element comprising a metal having a very small work function when covered with vaporized activating material whereby electron emission occurs only from the surface of said emitting element.

10. An improved electron source as claimed in claim 9 further defined by the surface of said emitting element comprising a metal from the group comprising zirconium, titanium and molybdenum.

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11. An improved electron source as defined in claim 10 further defined by said activating material comprising powdered barium aluminate.

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