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ELECTRON SOURCE
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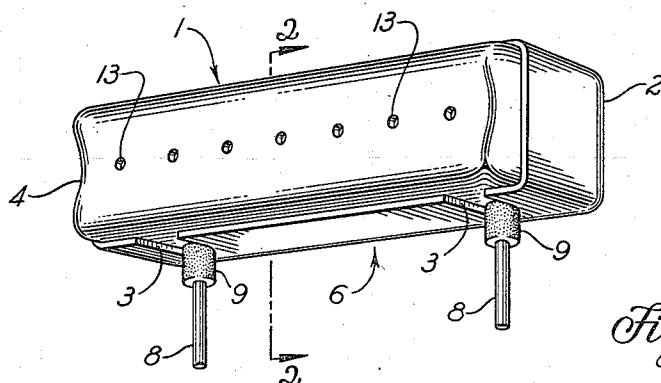


Fig. 1.

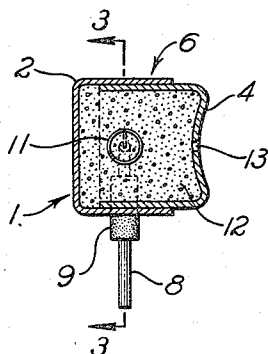


Fig. 2.

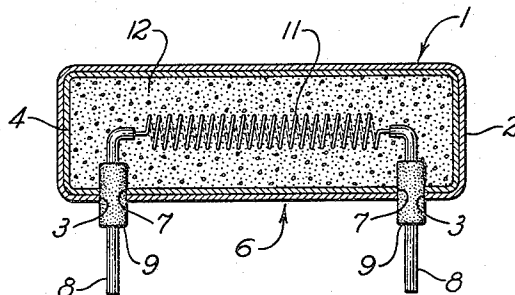


Fig. 3.

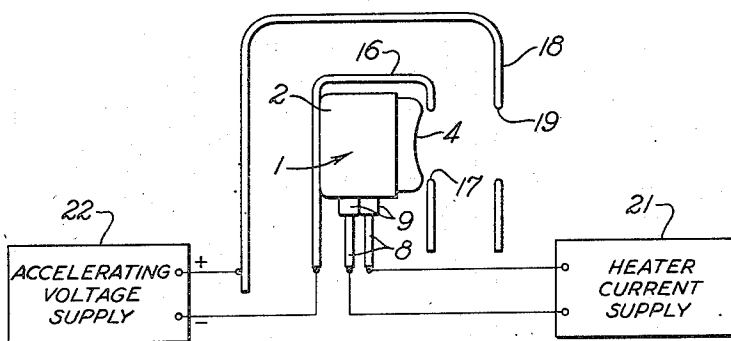


Fig. 4.

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ELECTRON SOURCE

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The present invention relates to an improvement in electron sources and is in particular concerned with an improved method and means for producing copious quantities of electrons in a controlled direction with a minimum power expenditure.

Of the known electron sources, probably the most efficient for high electron emissivity is the diffusion type wherein a material, such as thorium oxide, is diffused through a porous metal cathode structure and forms a thin electron emissive layer on the surface thereof which is continually replaced by the diffusion of more material through the metal of the cathode structure. An early advance in this art was made by A. W. Hull et al., Patent No. 2,107,945, who disclosed a woven or mesh structure enclosing an oxide of alkaline earth and a heater whereby diffusion through the mesh of the enclosed material creates an electron emissive surface exterior thereof. Numerous modifications and improvements upon this structure have been since advanced by others in the field; however, all require a relatively large power expenditure for any particular electron beam developed thereby. This requirement necessarily imposes limitations upon minimum size and associated power supplies which are generally undesirable and, at least in certain applications, are particularly troublesome. The present invention, by overcoming these requirements or limitations, provides an electron source particularly adaptable for electron beam apparatus, such as for example, certain types of vacuum tubes, cathode ray tubes, ion sources, and electron accelerating equipment; and this is achieved by the accomplishment of the following objects.

It is an object of the present invention to provide an improved electron source.

It is another object of the present invention to provide an improved method and means for producing an intense electron beam.

It is another object of the present invention to provide a method and means for producing an improved heat controlled electron emissive surface.

It is a further object of the present invention to provide an improved electron source having small power dissipation.

Numerous other objects and advantages of the invention will be apparent from the following disclosure taken together with the attached drawings wherein:

Figure 1 is a perspective view of a preferred embodiment of an electron source constructed in accordance with the principles of the invention;

Fig. 2 is a sectional view of the embodiment of Fig. 1 taken on plane 2—2 of Fig. 1;

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Fig. 3 is a sectional view of the embodiment of Fig. 1 taken on plane 3—3 of Fig. 2; and

Fig. 4 is a schematic illustration of one application of the improved electron source of the present invention and including cooperating power supplies.

Considering a preferred embodiment of the invention as shown in Figs. 1, 2, and 3 it will be seen that the electron source 1 comprises a first open-faced box 2 of generally rectangular configuration and having a pair of slots 3 therein extending away from one edge of the open face of box 2. Also provided is a second box or source face 4 consisting of a generally rectangular box-shaped element having an open face and having outside dimensions substantially identical to the inside dimensions of box 2 whereby face 4 slip fits into box 2 to form a closed cathode envelope 6. Source face 4 is preferably formed of a metal as noted below and is also provided with a pair of slots 7 extending away from an edge of the open side of source face 4 in a position to align with slots 3 in box 2 when face 4 is assembled with box 2. It will be appreciated that the slip-fit between face 4 and box 2 may be accomplished by making face 4 large enough to slip over the sides of box 2 or alternatively that innumerable types of mechanical connections may be made between face 4 and box 2 to form a desired envelope structure 6.

Envelope 6 is preferably supported by conductors 8 which may consist of rods or legs as shown and which extend into envelope 6 and thereby serve the dual function of supporting envelope 6 and providing electrical connections internal thereto. Envelope 6 is mounted upon conductors 8 by means of the slots 3 and 7 in box 2 and source face 4, respectively, and in assembly conductors 8 are slipped into slots 3 in box 2 and face 4 is thereupon slipped into contact with box 2 with slots 7 therein cooperating with conductors 8. The depth of slots 3 and 7 thus determine the degree of engagement of face 4 and box 2 so that the depth of these slots is designed to produce the desired relation between face 4 and box 2. In order to prevent electrical contact between envelope 6 and conductors 8, insulators 9 are provided about conductors 8 at the point where they engage the edges of slots 3 and 7 in box 2 and face 4, and the inner ends of these slots may be formed in such a configuration that they make intimate contact with insulators 9 on conductors 8; thereby substantially sealing the interior of envelope 6 at the point of entry of conductors 8.

Centrally disposed within envelope 6 is a heater unit 11 which extends between the ends of conductors 8 and is energized therethrough. Also

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within envelope 6 and substantially filling the interior thereof is an activating material 12 which may be in the form of a powder or the like and which provides a measure of support for heater unit 11. Activating material 12 completely surrounds heater unit 11 and extends therefrom to the inner surface of each of the walls of envelope 6 as shown; however, as will be apparent below, it is only necessary for the activating material 12 to extend between the heater and the inner surface of source face 4 with various mechanical schemes being adaptable to achieve this disposition.

An electron emissive surface is provided on electron source 1 by the inclusion of one or more minute apertures 13 in face 4 which in the illustrated embodiment are circular and aligned along the center of face 4. Apertures 13 provide for the flow of vapor from activating material 12 interior to envelope 6 to the outer surface of face 4 where an electron emissive surface is thereby formed.

Activating material 12 may consist of any suitable material, such as an oxide of an alkaline earth, which is volatile and which in combination with the material of face 4 forms an electron emissive surface. Also, face 4 is formed of a material which satisfactorily cooperates with the activating material to form an electron emissive surface having the desired properties. An example of a suitable combination is an activating material of barium aluminate and a face 4 formed of zirconium. The work function of the electron emissive surface formed depends upon the materials cooperating to form the surface and by proper choice of materials a very low work function may be obtained.

In operation the heater unit 11 is energized through conductors 2 as by a current source connected therebetween. The heat produced by heater unit 11 causes a part of the activating material 12 to volatilize and pass through apertures 13 in source face 4. This vapor passing through apertures 13 extends about the apertures to form a layer of substantially monoatomic thickness upon the outer surface of face 4 directly about apertures 13. The heat from energized heater unit 11 also raises the temperature of face 4 to an extent that electrons are emitted from the surface directly about apertures 13 where the monoatomic layer of activating material is disposed. Electrons are thus emitted from only a very limited area of face 4 as determined by the disposition of apertures 13 therein. In practice, apertures 13 are very minute and in fact the entire source 1 is generally quite small, of the order of one-half inch long, and a virtual line source may be obtained by positioning apertures 13 close enough together that the electron emissive surface about each abuts the electron emissive surface of the next adjacent. Although it is apparent that electrons are not emitted along a line because of the lack of emission in apertures 13 the small dimensions of apertures 13 and the very limited area surrounding the apertures that is electron emissive produces a virtual line source which for practical purposes can be considered and treated as a line source. It is also possible to utilize substantially all of the electrons emitted from face 4 by the provision of appropriate configuration thereof. In the illustrated embodiment wherein a line source is desired, face 4 is formed with a concave outer surface which serves to focus the emitted electrons in a manner to be explained in more detail below.

For a practical application of the improved

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electron source of the present invention, reference is made to Fig. 4 wherein there is illustrated a synchrotron injector mechanism including electron source 1 in end view. There is provided in substantially enveloping relationship to electron source 1 a shield 16 with an elongated aperture 17 therein in alignment with apertures 13 in face 4 and of a much greater size than the apertures. At a distance from shield 16 and in substantial parallelism therewith is a second shield or electrode 18 in which there is also provided an elongated aperture 19 of substantially the same size as aperture 17 in shield 16 and in alignment therewith.

Energization of the injector of Fig. 4 may be accomplished by the connection of heater current supply 21 across conductors 3 of electron source 1 whereby portions of source face 4 are rendered electron emissive, as set forth above. Removal of the electrons emitted from source 1 is accomplished by the establishment of an electrostatic accelerating field having a polarity such that electrons are attracted from source 1. This field is established by the application of a potential between shields 16 and 18 by means of an accelerating voltage supply 22 connected between shields 16 and 18. Outer shield or electrode 18 is connected to the positive terminal of accelerating voltage supply 22 so that electrons emitted from face 4 of source 1 are attracted toward shield 18 and pass through the aperture 19 therein in the form of a beam. In the illustrated embodiment of the synchrotron injector, shield 16 is electrically connected to the envelope 6 of source 1 which thereby results in the impression upon face 4 of a negative potential from accelerating voltage supply 22. The concave surface of face 4 is thus relatively negatively charged and, accordingly, there is applied to the electrons emitted from the vicinity of the center line of this concavity on face 4 an electrostatic force tending to repel the electrons. As the same force is exerted above and below the line of electron emission the emitted electrons are influenced to travel away from face 4 in a direction perpendicular to the line of emission rather than at some other angle and the emergent electron beam is thus focused into a line perpendicular to the plane of Figure 4.

The above disclosure of the invention has been made with reference to but a single embodiment and in connection with only one application thereof; however, it will be apparent that the numerous advantages of the invention may be realized by the utilization of the various modifications possible within the scope of the invention. For example, numerous combinations of activating materials and source face materials may be employed; the operating temperature being varied as a result. In this respect, the operating temperature of barium aluminate as the activating material with molybdenum is 1350° C., with zirconium is 1200° C., and with titanium is 1050° C. It will be appreciated that these temperatures need not be exactly attained and that electron emission naturally occurs over a range of temperatures; however, electron emission does decrease rather radically with temperature for substantial temperature variations from those quoted above.

By virtue of the novel electron source construction the amount of heat loss in the source is minimized and further, in distinction from common electron sources of the type replacing the emission surface, electron emission occurs only at the designed location whereby no prob-

lems or losses arise from extra or unwanted electron emission which cannot be efficiently utilized. It is also to be noted that construction of an electron emissive surface in accordance with the present invention materially intensifies and concentrates the beam of electrons available at a distance from the source and thus further increases the effective efficiency of the source. Under operating conditions an electron source constructed according to the present invention has been found to continually emit ten times the number of electrons available from a conventional heated tungsten filament. The advantages of having an electron emissive surface which is continually being replaced as in the present invention are multitudinous and include the lengthening of the life of the surface and protection of the metal backing under normal operation and the ability of the source to continue to emit normally during and after positive ion bombardment which would materially affect electron emission from conventional emission surfaces. Furthermore, the activating material is protected from destructive ion bombardment.

In view of the numerous advantages of the invention and variety of modifications possible thereunder, the present invention is not to be limited by the necessarily brief and exemplary illustration of the invention presented above, but instead the scope of the invention is to be measured solely by the appended claims.

What is claimed is:

1. An electron source comprising in combination a metal wall having a cylindrically concave surface and minute apertures formed through said wall along the line of maximum concavity, an activating material disposed contiguous with said wall on the opposite side thereof from said concavity and being readily vaporizable by heat, heating means adjacent said activating material for vaporizing said material and heating said wall whereby vaporized activating material passes through said apertures and coats the area directly adjacent thereto with a substantially monoatomic layer of activating material to form an electron emissive surface on said heated wall, and means establishing electrostatic lines of force extending perpendicular to the concave face of said metal wall whereby electrons emitted therefrom are focused into a substantial line parallel to said metal wall.

2. An electron source comprising a first box having an open side, a second box having an open side and a metallic side opposite thereto, said second box slidably engaging said first box to form a closed envelope, heating means disposed interior to said envelope, activating material disposed within said envelope about said heating means and transmitting heat therefrom to said envelope, said activating material being volatile upon the application of heat thereto, and the metallic side of said second box having minute apertures formed therein closely ad-

jacent and in a line of desired electron emission whereby vaporized activating material flows through said apertures and spreads in a substantially monoatomic layer upon said metal wall about said apertures to form in combination with said heated metal side an electron emissive surface having a configuration determined by the disposition of said apertures.

3. An electron source comprising an envelope having a metal wall, heating means internal to said envelope, and heating said envelope to substantially 1200 degrees centigrade, and powdered barium aluminate disposed within said envelope about said heating means, said metal wall having apertures therein whereby barium aluminate vaporized by heat from said heating means flows through said apertures to form a substantially monoatomic layer upon said metal wall, and said metal wall being formed of zirconium whereby copious quantities of electrons are emitted from the area directly adjacent said apertures and covered by said layer of barium aluminate.

4. An electron source as claimed in claim 3 wherein the heating unit heats the metal wall to substantially 1350 degrees centigrade and the metal face consists of molybdenum.

5. An electron source as claimed in claim 3 wherein the heating unit heats the metal wall to substantially 1050 degrees centigrade and the metal wall consists of titanium.

6. An electron source comprising a metallic envelope having a cylindrically concave surface thereon and a plurality of apertures therein along the line of maximum concavity, heating means interior to said envelope, an activating material about said heating means interior to said envelope and being volatile at the temperature of said heating means to slowly pass as a vapor through said apertures in the concave surface of said envelope and form a thin layer upon the exterior of said envelope adjacent said apertures and thereby in combination with said heated metal surface emit electrons, an electrode positioned from the concave surface of said envelope and having an aperture therein in substantial alignment with said concave surface, and power supply means impressing a potential between said electrode and said envelope with said envelope being electrically negative relative to said electrode whereby emitted electrons are focused into a beam and attracted away from said envelope through the aperture in said electrode.

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