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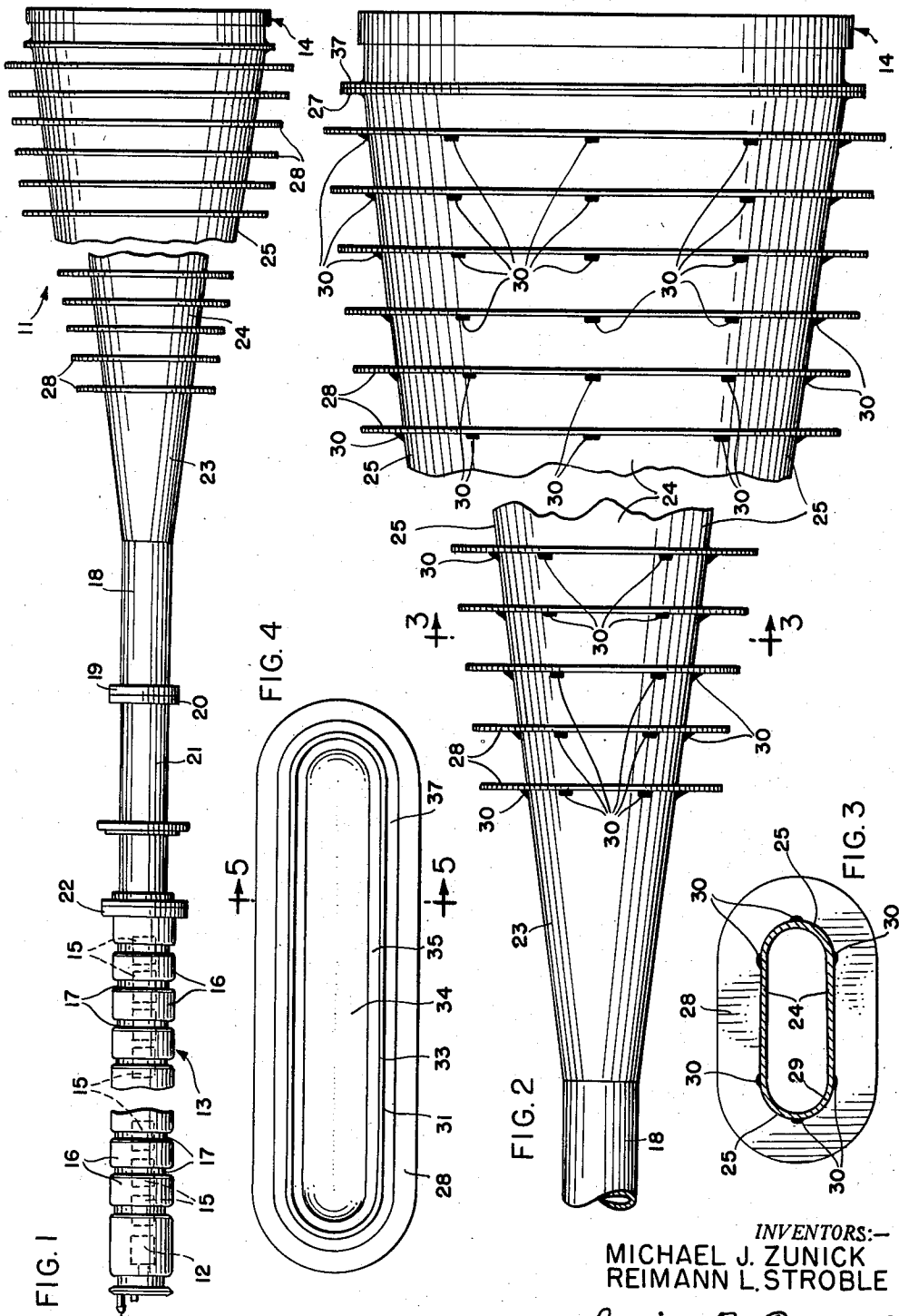
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ELECTRON FLOW APPARATUS AND METHOD OF MAKING SAME

Filed Dec. 13, 1955

2 Sheets-Sheet 1



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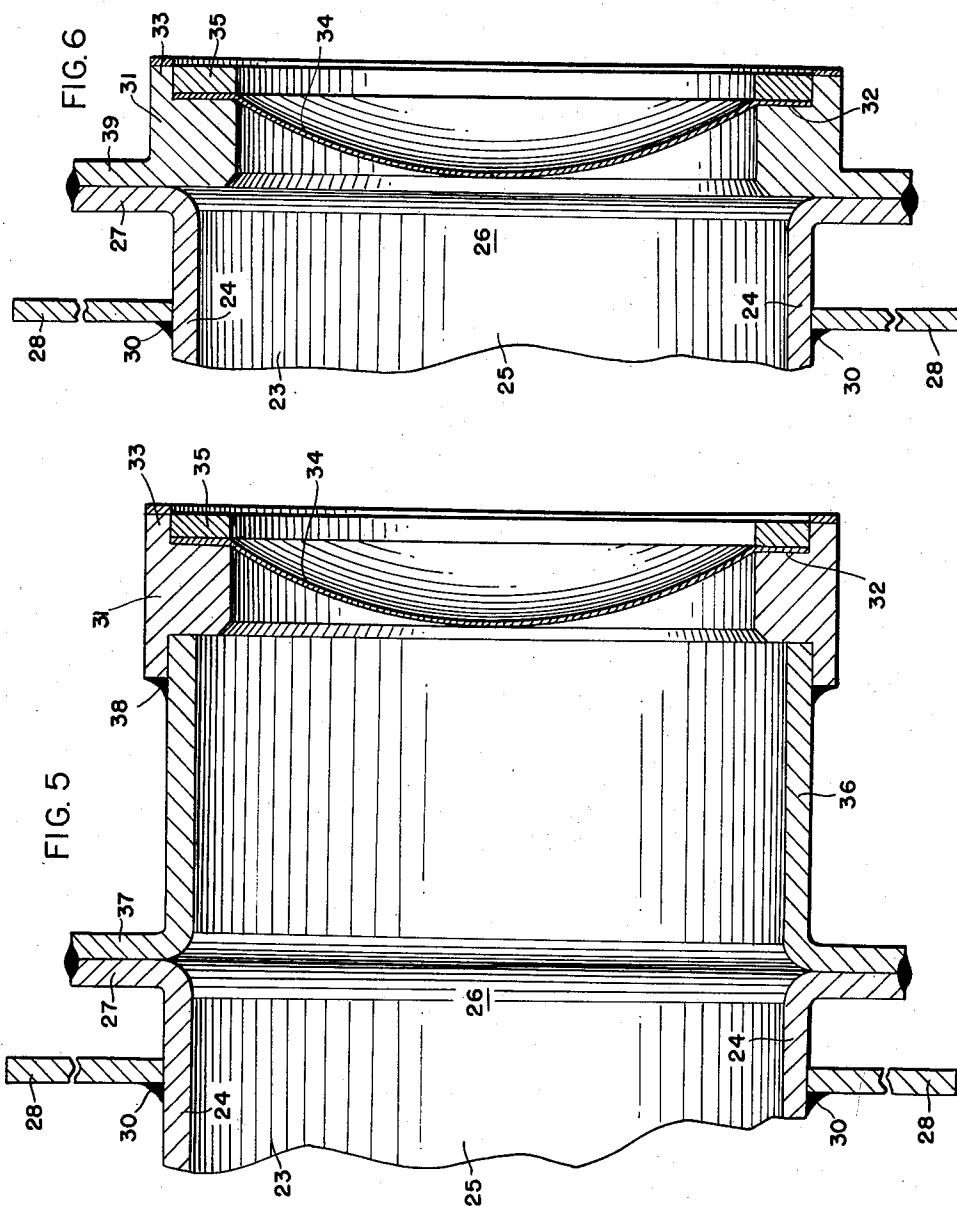
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ELECTRON FLOW APPARATUS AND METHOD OF MAKING SAME

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The present invention relates in general to electronics, and has more particular reference to apparatus for producing and controlling the flow of electrons, as in the form of an electron beam, the invention pertaining especially to improved high velocity electron flow apparatus and to novel methods of fabricating the same, and having specific application in electron flow devices designed for operation at ultra high electrical pressures of the order of several million volts.

Electron flow devices of the character mentioned may comprise an electron emitting cathode and a cooperating anode supported in spaced apart, electrically insulated alignment, as by means of a suitable elongated envelope, commonly embodying glass as an insulating medium disposed between the cathode and anode, such envelope enclosing and defining an electron flow path between the cathode and anode, provision being made for the application of electrical potential of desired magnitude between the anode and cathode for the purpose of driving cathode emitted electrons toward the anode.

It should be understood that electron discharge devices may be caused to operate by exciting the cathode for electron emission and by applying electrical potential, between the anode and cathode of the device, to drive cathode emitted electrons toward the anode, the envelope of the device being maintained under low pressure, substantially vacuum conditions to form a suitable electron flow path within the envelope between the cathode and the anode.

In devices of the character mentioned, the anode commonly comprises a tubular element mounted upon and at the cathode remote end of the envelope of the device, in coaxial alignment with the electron emitting cathode, said tubular anode element forming an extension of the enclosing envelope. Where the device is constituted as an electron beam generator, the tubular anode element, as at its cathode remote end, may be closed by a panel of material which is substantially transparent to electrons and which, consequently, may function as an efficient electron transmitting window permitting substantially unhampered delivery of cathode emitted electrons outwardly of the envelope. Such window panels, of course, are not entirely transparent to the passage of electrons therethrough, and consequently are usually made as thin as possible to afford minimum obstruction to the passage of electrons, the window panels preferably being merely thick enough to sustain required low pressure conditions within the envelope of the device.

Heretofore it has been customary to utilize tubular anode elements of circular sectional shape in electron flow devices of the character mentioned, such anode elements containing transmitting windows of circular peripheral configuration, as shown more especially in U.S. Letters Patent No. 1,936,424 of November 21, 1933, on the invention of William D. Coolidge in Electrical Discharge Device. Because of the thin, flimsy character of the transmitting window pane and its consequent relative weakness as a self-supporting member, especially

when exposed to the low pressure conditions necessarily maintained within the envelope, there is a definite limit to the size of circular windows and hence of window mounting tubes that may be employed, without increasing the thickness of the window pane, and thereby diminishing its electron transmitting efficiency, or otherwise providing internal support for the pane. It is nevertheless desirable to provide for the emission of electrons from a generator of the character described within a wide field or zone, to thereby allow application of such emitted electrons for useful purposes, such as the electron irradiation of exposure objects of large size, within such wide field.

An important object of the present invention is to provide an improved electron beam generating and emitting device embodying a hollow anode element having an electron emitting end of narrow elongated configuration, said extension being laterally flared whereby electrons may be emitted at said end within a relatively wide, though shallow, emission zone, through a narrow elongated window pane element of minimal thickness sealed in the electron emitting end of said extension.

Another important object is to provide an improved electron beam generating and emitting device embodying a hollow anode element preferably comprising sheet metal and having laterally flared, relatively flattened configuration defining a narrow elongated electron transmitting window at an end thereof, including a plurality of strengthening ribs formed in spaced relation on said flared element to prevent collapse thereof when exposed to low pressure conditions within the extension; a further object being to form said ribs peripherally around said flared and flattened anode element; a still further object being to provide strengthening ribs comprising separately formed rings configured in accordance with the sectional shape of said flared element and hence adapted to embrace the same; a still further object being to form said rings as sheet metal stampings and to secure the same in place upon the anode extension as by welding the same thereto.

Another important object is to provide an improved electron beam generating and emitting device embodying a hollow anode element formed of sheet metal and defining an electron transmitting window opening of narrow elongated configuration at an end thereof, and a metal window pane of foil-like character sealingly closing said opening; a further object being to form the window pane element of titanium metal and to mount the same in the structure by brazing the edges of the pane element in a steel frame, by means of silver or the alloy of silver with copper, manganese or nickel, as brazing material, the steel window frame being thereafter peripherally arc welded and hence sealed in the electron emitting end of the anode element; a still further object being to form the window pane element as a foil-like sheet of stainless steel sealed at high temperature, either in vacuo or in a hydrogen atmosphere, to a window frame of copper or stainless steel, by means of gold or silver or alloys thereof, the window frame being thereafter sealed in the electron emitting end of the anode element.

Another important object is to provide an electron transmitting window for an electron beam generator comprising a foil-like strip of metal of narrow, relatively elongated configuration, and preformed to concave shape, thereafter sealed at the edges of the window pane element in a mounting frame adapted to be sealed in the electron emitting end of an anode extension of the electron generator.

Briefly stated, in accordance with one of its aspects, the present invention contemplates the provision of an improved electron beam generator embodying an electron emitting cathode enclosed in one end of an elongated in-

ulating envelope having a hollow extension forming an anode at the cathode remote end of the envelope, said extension comprising sheet metal and being flared outwardly toward its cathode remote end and flattened to form an electron emitting funnel providing a narrow elongated electron transmitting window at the cathode remote end of the extension, the flared and flattened portions of said extension being provided with peripheral strengthening ribs comprising flange forming rings embracing and conforming with the shape of the flared portions of the extension, such rings being secured as by welding in spaced apart relation on said extension, and a thin, foil-like narrow elongated window pane having inwardly curved concave configuration, sealed at its edges in said extension at the cathode remote end thereof.

The foregoing and numerous other important objects, advantages and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment of the invention.

Referring to the drawings:

Fig. 1 is a side view of a high voltage electron beam generator embodying the present invention;

Fig. 2 is a greatly enlarged view of a portion of the device shown in Fig. 1;

Fig. 3 is a sectional view taken substantially along the line 3—3 in Fig. 2;

Fig. 4 is a view of the structure shown in Fig. 2 as seen from the right hand end thereof;

Fig. 5 is an enlarged sectional view taken substantially along the line 5—5 in Figs. 2 and 4; and

Fig. 6 is a sectional view like Fig. 5 and showing a modified construction.

To illustrate the invention, the drawings show an electron beam generator comprising a hollow anode 11 and a cathode 12 supported in spaced apart, relatively insulated facing alignment, as by means of an elongated insulating envelope portion 13 of generally tubular configuration and enclosing the cathode therein, at one end, said envelope portion carrying the anode, as an extension thereof at its other or cathode remote end, said envelope portion 13, defining an electron flow path between the cathode and the anode.

The cathode may be of any suitable, convenient or preferred character, and may embody an electron emission filament mounted in a conventional focusing structure, the cathode being sealed within an end of the envelope portion 13 and suitable conductor means being provided for exciting the filament for electron emission by electrically connecting the same with a source of filament energizing power disposed outwardly of the envelope. As shown, the anode 11 may comprise a hollow elongated element mounted upon and sealed to the cathode remote end of the envelope portion 13 in coaxial alignment therewith, thereby constituting the anode as a portion of the envelope, the outer or cathode remote end of the anode element being formed with an electron transmitting window structure 14 for the delivery therethrough of a useful electron beam outwardly of the anode element.

It should be understood that electron beam generators of the character described may be operated by applying electron driving potential between the anode and the cathode, in order to cause electrons, emitted in the cathode in response to excitation thereof, to travel through the envelope 13 from the anode toward the cathode. In order to guide and accelerate electrons, while traveling through the envelope from the cathode toward the anode, a series of electrodes 15, comprising metal sleeves forming electronic lenses may be mounted in end to end alignment within the envelope 13 between the anode and cathode, as suggested, for example, in U.S. Letters Patent No. 2,144,518, which issued January 17, 1939 on the invention of W. F. Westendorp, in High Voltage Apparatus, means being provided to electrically energize the elec-

trodes at progressively increasing potential values away from and with respect to the cathode, whereby electron movement between cathode and anode may be accelerated by the action of the charged electrodes 15.

Electron beam generators of the sort herein contemplated are adapted for operation at relatively high values of electron driving potential applied between the anode and cathode which, accordingly, are of necessity relatively widely spaced apart, thereby requiring an intervening envelope structure 13 of elongated character disposed between the anode and cathode of the device, the required envelope length between anode and cathode, in ultra high voltage devices, being such as to render difficult the provision of a homogeneous envelope structure of material, such as glass. Accordingly, the envelope portion 13 preferably comprises a series of sleeve-like envelope sections 16 secured together in end to end abutting relationship, as by means of metal seal members 17 interposed between the glass sections 16 and forming glass-to-metal seals therewith to constitute the envelope portion 13 as a sectionalized structure of the sort shown, for example, in U.S. Letters Patent No. 2,336,774, which issued December 14, 1943 on the invention of Howard W. Brackney and Joseph B. Gosling, in X-Ray Tube, or as described in the application for U.S. Letters Patent on the invention of Michael J. Zunick and George R. Mahn, for Electron Flow Device, which is to be filed shortly and which is presently identified as attorney's docket number 23D-468.

After passing from the cathode and through the sectionalized envelope portion 13, electrons may enter the anode element 11, and after traversing the same, may be delivered thence as a useful beam of electrons, through the window structure 14, at the cathode remote end of the anode element. In order to provide for the application of electrons upon articles of large size, it is, of course, desirable to provide for electron emission over as wide an emission field or zone as is possible, and it has heretofore been customary to provide a window structure embodying a circular window pane of the required size, and to make the window pane thick enough to sustain the low internal pressure necessarily maintained within the envelope for the device when in operation. As shown, for example, in U.S. Letters Patent No. 1,936,424, aforesaid, which issued November 21, 1933, on the invention of William D. Coolidge in Electrical Discharge Device, it has been customary to provide supporting grids or grills behind large electron transmitting windows in order to sustain the same against collapse under the low pressure conditions necessarily maintained within the hollow anode element as a part of the evacuated envelope of the device. Such supporting grills, of course, absorb electrons and hence appreciably reduce the electron emitting efficiency of the window structure.

The present invention seeks to provide for electron emission a maximum efficiency through the window structure 14 within a wide emission field or zone. To this end, the anode element 11 preferably comprises a hollow member formed of relatively thin sheet material, such as stainless steel, the hollow member comprising a cylindrical pipe portion 18 formed at one end for connection with the cathode remote end of the sectionalized envelope portion 13. As shown, the pipe portions may be formed with an end flange 19 adapted for connection, as by means of a peripheral weld, with a cooperating flange 20 formed at one end of a pipe 21, the other end of the pipe 21 being sealingly secured to a collar 22 forming the cathode remote end of the sectionalized envelope portion 13.

The anode element 11 also comprises a laterally flared portion 23, forming a flat funnel having an end secured to the end of the pipe portion 18 remote from the flange 19, said flared portion 23 being continuous with and forming an extension of the pipe portion 18. The portion 23 is flared outwardly, progressively away from the pipe portion 18, and is flattened so that said portion comprises

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a pair of flat parallel walls 24 and integral wall portions 25 of semicircular configuration interconnecting the opposite flaring sides of the flat wall portions 24. Such flared and flattened configuration provides a relatively narrow elongated window opening 26 at the end of the portion 23 remote from the tubular portion 18, said end being preferably formed with an integral outstanding flange 27.

The foregoing flared configuration of the envelope extension permits a beam of electrons, delivered through the tubular portion 18 and into the flared portion 23, to be oscillated rapidly back and forth, between the opposite curved sides 25 of the flared portion, as it passes therethrough and outwardly of the window structure 14, such oscillation of the beam being caused and controlled by suitable magnetic deflection or sweep coils disposed outwardly of the anode element 11, as at the junction of the tubular portion 18 with the flared portion 23. It will be obvious, of course, that the oscillating electron beam thus emitted through the window structure 14 will traverse a relatively wide zone of shallow depth outwardly of said window structure.

In order to render the flared and flattened anode extension safely self supporting under the low pressure conditions necessarily maintained within said extension when the generator is in operation, the same may be formed with a plurality of spaced apart strengthening ribs 28, preferably comprising plates, each formed with an opening 29 therethrough and shaped to conform with and to embracingly receive the flared portion 23 of the anode element, at the place where the plate is mounted thereon. The plates 28, accordingly, may be of like width and of progressively increasing length; and they may be assembled upon the flared portion 23 by applying the same about the tubular portion 18 in succession, commencing with the plate having the largest opening 29, and by moving the plates longitudinally to seated position on the flared portion 23. The plates may be secured on the flared portion 23 in any suitable or convenient fashion, preferably by spot welding the plates to the flared portion, as indicated at 30; or by fusion welding, if desired. So applied, the plates 28 will adequately support the spaced apart flat sides of the flared portion 23 against inward collapse when the interior of the envelope, including the hollow anode element 11, is evacuated.

The window structure 14 preferably comprises a frame 31, as of copper or stainless steel, shaped in conformity with the opening 26 at the cathode remote end of the extension 11, said frame forming a peripheral seat 32 defined within a retaining rib 33 for receiving the marginal edges of a window pane element 34 of foil-like character having thickness of the order of 6 ± 4 mils. While the broader aspects of the present invention are not necessarily limited to any particular window pane material, the pane 34 may conveniently comprise stainless steel or titanium metal. The marginal edges of the pane element 34 may be held in the seat 32 as by means of a retaining collar 35 shaped to fit upon the seat 32 in position overlying the marginal edges of the pane element, within the peripheral rib 33. The marginal edges of the pane element 34 and the retaining collar 35 may be secured together and sealingly integrated with the frame 31 as by means of a suitable brazing medium. Where the window pane element 34 comprises titanium metal, the frame 31 and retaining collar 35 preferably comprise stainless steel; and the parts are preferably sealed by brazing the same, at high temperature and in vacuo, by means of brazing material comprising silver or the alloys of silver with copper, manganese or nickel. Where the pane element 34 comprises stainless steel, the frame 31 and the retaining collar 35 may comprise copper or stainless steel; and the parts may be sealed together at high temperature in vacuo or in a reducing atmosphere, as

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in a hydrogen furnace, with gold or silver, or alloys thereof, as brazing material.

If desired, the window pane element 34 may be applied and sealed in the frame 31 while in flat condition. It will, however, assume an inwardly bowed or concave configuration, as shown in Figs. 5 and 6, under the influence of vacuum conditions maintained within the envelope and the anode extension; and it is, therefore, preferable to preform the window pane element 34 to the inwardly bowed configuration shown in Figs. 5 and 6 before sealing the edges thereof in the frame 31. Such preforming may be accomplished by mounting the pane element, in flat condition, in a suitable edge holding jig, by thereafter heating the pane element, as by electrically energizing the same to employ its electrical resistance in accomplishing the heating, and by applying differential air pressure on opposite sides of the heated element.

As shown in Fig. 5, the window structure may be applied to the flanged end 27 of the anode element 11 by means of a mounting collar 36, as of steel, having a flange 37 at one end adapted to be peripherally welded to the flange 27 of the extension, the pane carrying frame 31 being brazingly sealed, as at 38, to the opposite end of the sleeve 36. The structure shown in Fig. 5 may be employed to advantage where the frame 31 is of steel or of copper. Where the frame 31 is of steel, however, it may, as shown in Fig. 6, be provided with an outstanding flange 39 adapted to be peripherally welded directly to the flange 27 of the extension 11.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit and scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. Electron discharge apparatus comprising an electron emitting cathode and a cathode enclosing envelope having a metal portion defining a narrow elongated window opening in said envelope and a peripheral seat at said opening, a window pane of foil-like material having edges engaging said seat and a sealing ring overlying said edges in said seat and brazingly secured to said metal portion to thereby seal the edges of said window pane in said seat in position closing said opening.
2. Electron discharge apparatus as set forth in claim 1 wherein the window pane comprises stainless steel.
3. Electron discharge apparatus as set forth in claim 1 wherein the window pane comprises titanium.
4. Electron discharge apparatus as set forth in claim 1 wherein said window pane comprises titanium brazed at its edges to the carrying frame by means of a brazing medium selected from the class consisting of silver and the alloys of silver with copper, manganese and nickel.
5. Electron discharge apparatus as set forth in claim 1 wherein said window pane comprises stainless steel brazed at its edges to the carrying frame by means of a brazing medium selected from the class consisting of gold, silver and the alloys of gold and silver with copper, manganese and nickel.
6. Electron discharge apparatus as set forth in claim 1, wherein the window pane comprises a sheet of metal having thickness of the order of 6 ± 4 mils.
7. Electron discharge apparatus as set forth in claim 1, wherein the window pane is brazingly secured in the peripheral seat by means of a brazing medium comprising gold.
8. Electron discharge apparatus as set forth in claim 1, wherein the window pane is brazingly secured in the peripheral seat by means of a brazing medium comprising silver.

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9. Electron discharge apparatus as set forth in claim 1, wherein the window pane is brazingly secured in the peripheral seat by means of an alloy containing gold as an alloy component.

10. Electron discharge apparatus as set forth in claim 1, wherein the window pane is brazingly secured in the peripheral seat by means of an alloy containing silver as an alloy component.

11. Electron discharge as set forth in claim 1, wherein the window pane is brazingly secured in the peripheral seat by means of an alloy forming a brazing medium and including, as alloy components, gold and a metal selected from the class consisting of copper, manganese and nickel.

12. Electron discharge apparatus as set forth in claim 1, wherein the window pane is brazingly secured in the

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peripheral seat by means of an alloy forming a brazing medium and including, as alloy components, silver and a metal selected from the class consisting of copper, manganese and nickel.

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