May 13, 1969 SUSUMU YOSHIDA ET AL 3,444,416

ELECTRON EMITTING DEVICE AND METHOD OF ASSEMBLING THE SAME

Filed Sept. 6, 1967 Sheet 1 of 2

FIG. 1.

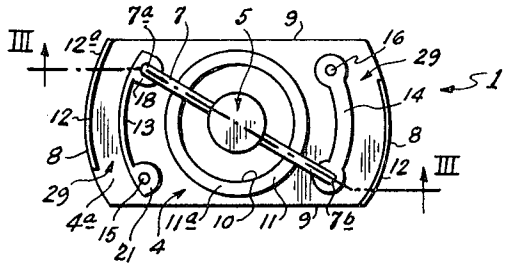


FIG. 2.

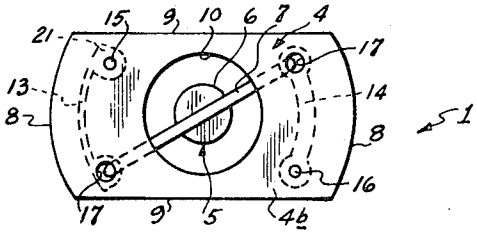
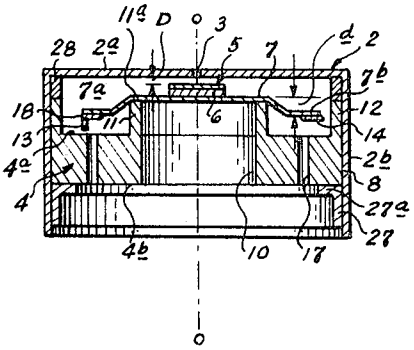


FIG. 3.



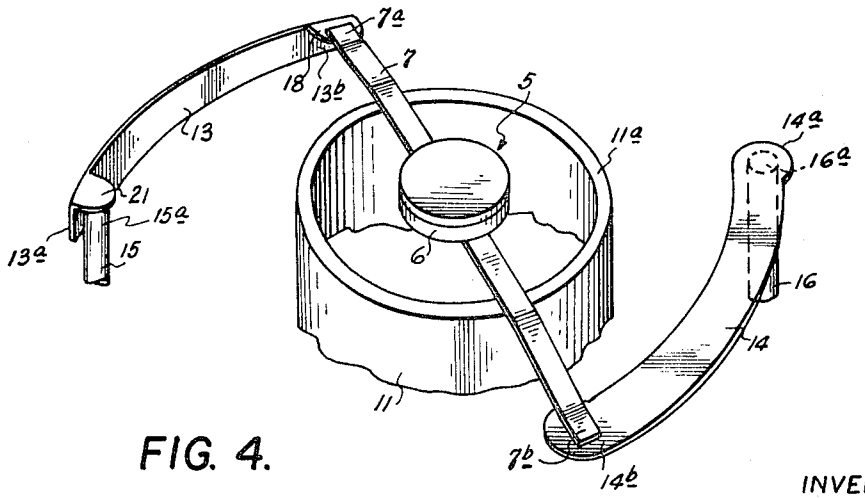


FIG. 4.

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FIG. 6.

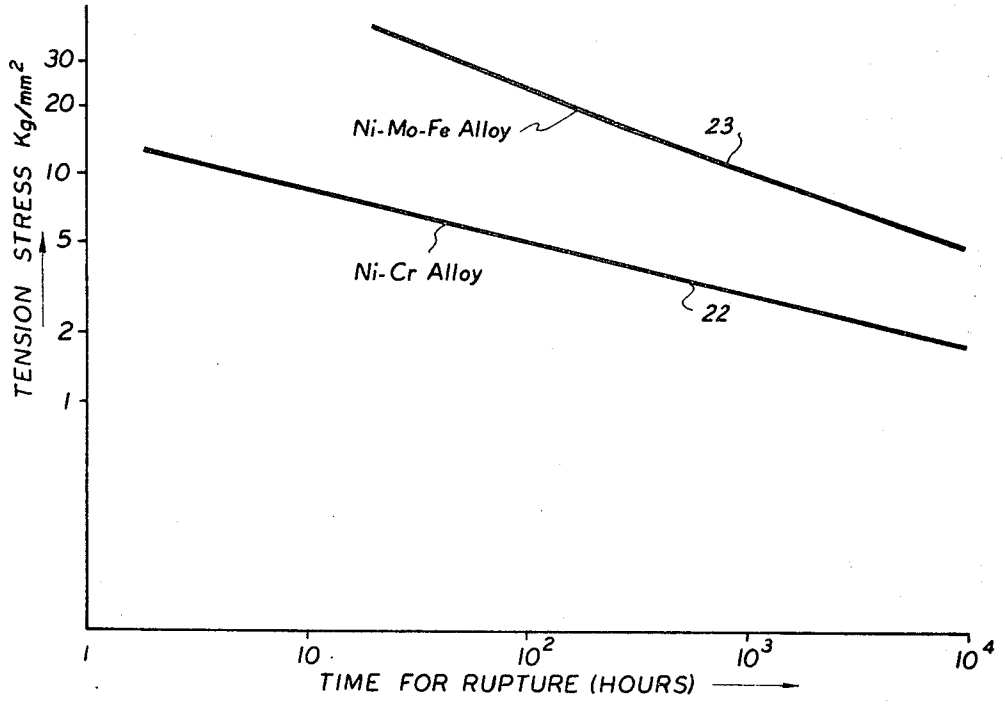
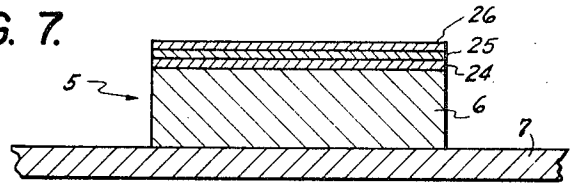


FIG. 7.



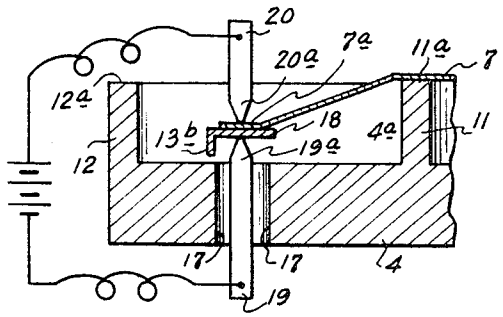


FIG. 5.

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3,444,416

ELECTRON EMITTING DEVICE AND METHOD OF ASSEMBLING THE SAME

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Int. Cl. H01j 1/94, 19/48
U.S. Cl. 313—270 13 Claims

ABSTRACT OF THE DISCLOSURE

In an electron emitting device, an insulating member has an anuular support ledge projecting from a face thereof, an elongated heater element preferably of a Ni-Mo-Fe alloy extends diametrically across the support ledge and carries a thermion emitting member substantially centered with respect to the ledge, leaf springs are mounted at one end at locations on the insulating member that are outside the ledge and have their other ends secured to the heater element ends, one of the springs is resiliently flexible parallel to the plane of the edge surface of the ledge to longitudinally tension the heater element and the other spring is resiliently flexible in directions generally normal to such plane to hold the heater element against the ledge, and the insulating member with the heater element thus mounted thereon is fixed in a grid structure having a central aperture in an end wall thereof with the thermion emitting member at a predetermined, invariable distance from such aperture.

This invention relates to an electron emitting device which is particularly adapted to serve as the electron gun of cathode-ray tubes, for example, television picture tubes.

An object of this invention is to provide an electron emitting device which is of simple structure and easy to produce.

Another object is to provide an electron emitting device which operates with low power and high efficiency and which reaches its full operating condition after a short heating period.

A further object is to provide an electron emitting device which has a stable cut-off characteristic and a uniform cut-off voltage, that is, a cut-off voltage not subject to variation.

Still another object of the invention is to provide a method by which the elements of an electron emitting device can be easily and realiably assembled together.

In accordance with an aspect of this invention, an electron emitting device is provided with an insulating member having a support ledge which is desirably annular so that diametrically opposed portions of such ledge are spaced apart laterally in a common plane, an elongated heater element extending across the space between the diametrically opposed portions of the ledge and having ends projecting beyond the ledge, a thermion emitting member on the heater element which is centered with respect to the opposed portions of the ledge on which the heater element is intended to seat, two spring members mounted on the insulating member at the outside of the ledge and having ends which are connected to respective ends of the heater element, one of the spring members being resiliently flexible in directions generally parallel to the common plane of the opposed ledge portions to longitudinally tension the heater element, and the other spring member being resiliently flexible in directions generally normal to such common plane to hold the heater element in contact with the opposed ledge portions whereby, when the insulating member is fixed within a grid structure with the ledge at a predetermined distance from a centrally apertured end wall of the grid structure, the thermion emitting member is located at a fixed distance with respect to the central aperture of such end wall even though the heater element is thermally expanded or is subjected to external shocks or vibrations, thereby to ensure a stable cut-off characteristic and a uniform cut-off voltage.

In arcordance witha feature of this invention, the elongated heater element is formed of a Ni-Mo-Fe alloy which is characterized by a substantially large rupture strength and durability in prolonged use, and which further has relatively low resistivity to reduce power consumption and also a relatively small thermal expansion coefficient.

It is another feature of this invention to form the thermion emitting member from a metal base fixed to the heater element and on which there are superposed three electron emitting oxide layers, with the layer closest to the metal base and the layer farthest from the base containing a metal which strongly resists oxidation in addition to the electron emitting oxide.

The above, and other objects, features and advantages of the invention, will be apparent from the following detailed description of an illustrative embodiment thereof which is to be read in connection with the accompanying drawings, wherein:

FIG. 1 is an enlarged top plan view of an electron emitting device in accordance with this invention;

FIG. 2 is a bottom plan view of the device shown in FIG. 1;

FIG. 3 is a sectional view taken along the line III—III on FIG. 1, and showing the electron emitting device of FIGS. 1 and 2 fixed in relation to a grid structure;

FIG. 4 is an enlarged perspective view illustrating the mouting of a heater element in the electron emitting device according to this invention;

FIG. 5 is a detail sectional view illustrating the method in accordance with this invention by which a heater element is assembled together with its mounting springs in an electron emitting device in accordance with this invention;

FIG. 6 is a graphic representation of the relationship between the tension stress applied to a heater element and the time required for its rupture when subjected to a high temperature in the case of a heater element formed of a particular alloy in accordance with this invention, and also in the case of a heater element formed of an alloy as previously proposed; and

FIG. 7 is an enlarged detail sectional view illustrating the construction of a thermion emitting member provided in the device according to this invention.

Referring to FIGS. 1, 2 and 3 in detail, it will be seen that an electron emitting device in accordance with this invention as there shown and generally identified by the reference numeral **1** is intended to be assembled together with a metal grid structure **2** composed of an end wall **2***a* having a central aperture **3** and a side wall **2***b* extending from the perimeter of end wall **2***a* at right angles to the latter (FIG. 3).

The electron emitting device **1**, as shown, comprises an insulating member **4**, for example, of a ceramic, on which there is mounted, as hereinafter described in detail, an elongated or ribbon-type heater element **7** carrying, intermediate its ends, a thermion emitting member **5** formed by a metal base or disk **6** which is covered by layers of thermion emitting oxides and has a diameter substantially larger than that of the aperture **3** of the grid structure.

In the embodiment shown, the insulating member **4** has parallel, generally flat top and bottom faces **4***a* and **4***b* and side surfaces that include part-cylindrical surfaces **8** concentric with the center of the insulating member and chordal or straight, parallel surfaces **9** extending between the ends of surfaces **8**, with such surfaces **8** and **9** being directed normal to the faces **4***a* and **4***b*. The insulating member **4** is dimensioned to fit closely within the side wall **2***b* of grid structure **2** with at least surfaces **8** of the insulating member closely engaging the inner surface of side wall **2***b* so as to dispose faces **4***a* and **4***b* of the insulating member parallel to end wall **2***a* of the grid structure. The side wall **2***b* of the grid structure may be cylindrical and have an internal diameter equal to the diameter of the part-cylindrical surfaces **8** of the insulating member, or side wall **2***b* may be shaped to conform to the configuration of side surfaces **9** of the insulating member as well as to the part-cylindrical surfaces **8** thereof.

Insulating member **4** has a central aperture **10** extending therethrough perpendicular to faces **4***a* and **4***b* and having a diameter substantially larger than that of the base **6** of thermion emitting member **5**. An annular ledge **11** projects, at right angles, from face **4***a* around aperture **10** and its edge surface **11***a*, which lies in a plane parallel to that of face **4***a*, defines a support seat for heater element **7** at diametrically opposed portions of the ledge. Arcuate rims or flanges **12** also project from face **4***a* of the insulating member at locations spaced outwardly from annular ledge **11**, for example, along the part-cylindrical side surfaces **8**, as shown. Such arcuate rims or flanges **12** may have a height equal to that of ledge **11**, as shown on FIG. 3.

In order to mount heater element **7** on insulating member **4**, device **1** in accordance with this invention further includes two leaf springs **13** and **14** which may be arcuate, as shown, and which are disposed over face **4***a* in the gaps between ledge **11** and rims or flanges **12**. Ends **13***a* and **14***a* of leaf springs **13** and **14** are secured, for example, by means of welding, to ends **15***a* and **16***a* of lead or terminal pins **15** and **16** which extend through insulating member **4** perpendicular to faces **4***a* and **4***b* and which are fixed to the insulating member. The other or free ends **13***b* and **14***b* of leaf springs **13** and **14** are secured, as by welding, to the ends **7***a* and **7***b*, respectively, of heater element **7** which project beyond ledge **11**, whereby heater element **7** is mounted on springs **13** and **14** and diametrically bridges or spans ledge **11**.

As shown particularly on FIG. 3, the ends **13***b* and **14***b* of the springs which are connected to the ends of heater element **7** are preferably offset from the plane of the edge surface **11***a* of ledge **11** in the direction away from that in which such edge surface **11***a* faces, that is, in the direction toward face **4***a* of the insulating member so that, as viewed on FIG 3, the ends of the heater element connected to the springs are disposed below the central or major portion of the length of heater element **7** which diametrically spans ledge **11**.

In accordance with the present invention, leaf spring **13** is resiliently flexible in directions generally parallel to the plane of ledge surface **11***a* while leaf spring **14** is substantially inflexible in those directions, whereby spring **13** serves to longitudinally tension elongated heater element **7**. Further, leaf spring **14** is resiliently flexible in directions perpendicular or normal to the plane of ledge surface **11***a* and spring **13** is substantially inflexible in such directions normal to the plane of ledge surface **11***a*, whereby spring **14** urges the longitudinally tensioned heater element **7** against ledge surface **11***a* at the diametrically opposed locations where the heater element crosses the ledge. The foregoing characteristics of leaf springs **13** and **14** are readily obtained by arranging such springs so that the major axes of their rectangular cross-sections are respectively directed normal or perpendicular to, and parallel to the plane of ledge surface **11***a*. The pins **15** and **16** which carry springs **13** and **14** are preferably disposed symmetrically, at opposite sides of the central axis **0—0** (FIG. 3) of insulating member **4**, and the springs **13** and **14** are dimensioned and disposed to similarly position the ends **7***a* and **7***b* of the heater element symmetrically at opposite sides of such axis **0—0**.

In order to facilitate welding of springs **13** and **14** to pins **15** and **16** and to ends **7***a* and **7***b* of the heater element, the end portions of the arcuate rims or flanges **12** which are adjacent pins **15** and **16** are preferably cut away or notched, as at **29** on FIG. 1, and the insulating member **4** is formed with bores **17** extending therethrough perpendicular to face **4***a* and opening through the latter at locations aligned with the ends **13***b* and **14***b* of the springs.

In assembling together the various elements of the electron emitting device **1** in accordance with this invention, an ear **21** provided at the end **13***a* of spring **13** is disposed on the end **15***a* of terminal pin **15** and spot welded thereto using, as the electrodes for such spot welding, the pin **15** itself and an electrode (not shown) which is applied against the ear **21** from above. The end **13***a* of the spring can be further welded to the side of end portion, a near **21** provided at the end **13***a* of spring **13** is the welding electrodes, while the other electrode is extended laterally through the adjacent cut-out or notch **29** of rim **12** and engaged laterally against the outer surface of end **13***a* of the spring. Similarly, the end **14***a* of spring **14** is spot-welded on the end surface **16***a* of pin **16** using the latter as one of the welding electrodes while the other electrode is applied from above against end **14***a* of the spring.

Having thus secured springs **13** and **14** on pins **15** and **16**, heater element **7** is extended across ledge **11** so that its ends **7***a* and **7***b* respectively rest on an ear **18** projecting from the end **13***b* of spring **13** and on the end **14***b* of spring **14**. Then, as shown specifically on FIG. 5, a welding electrode **19** is extended upwardly through the bore **17** of insulating member **4** which is aligned with end **13***b* of spring **13**, whereby to contact the tip **19***a* of such welding electrode with the underside of ear **18**. Another electrode **20** is directed downwardly from above so as to engage its tip **20***a* with the end **7***a* of the heater element, whereupon a pulsing current is supplied to electrodes **19** and **20** from a suitable source to spot weld end **17***a* of the heater element to the ear **18** on spring **13**. The end **7***b* of the heater element is then similarly spot welded to end **14***b* of spring **14**, with one of the electrodes employed for that purpose being extended upwardly through the bore **17** in the insulating member which is aligned with spring end **14***b*.

Heater element **7** of the electron emitting device in accordance with this invention is preferably formed of a Ni-Mo-Fe alloy in which the proportions of the alloying constituents are, by weight, from 4 to 6% Fe, from 25 to 30% Mo, and the balance Ni. A particularly desirable alloy for the heater element **7** contains, by weight, 5% Fe, 28% Mo and 67% Ni. When such alloy is used for forming heater element **7**, the Ni content contributes malleability, the Mo content provides the required hardness, and the Mo and Fe contents determine the resistivity of the heater element. The heater element **7** formed of the described alloy is characterized by a relatively high rupture strength and durability when subjected to the high operating temperatures for prolonged periods of use, while such alloy is easy to fabricate in giving the heater element its elongated, ribbon-like configuration. Furthermore, the heater element **7** formed of the described alloy has a relatively small resistivity, and thereby reduces the power consumption of the electron emitting device. Furthermore, the thermal expansion coefficient of the described alloy is relatively small so that the positional stability of the heater element **7** formed therefrom can be readily achieved through the action of springs **13** and **14**.

It has been previously proposed to form a heater ele-

ment of an electron emitting device of a Ni-Cr alloy. Referring to FIG. 6, it will be seen that the durabilities, that is, the times required for rupture, of a heater element formed of such Ni-Cr alloy when subjected to various tension stresses, as indicated by the curve **22**, are very substantially less than the durabilities of a heater element formed of the Ni-Mo-Fe alloy previously described herein, as indicated by the curve **23**. The curves **22** and **23** both represent the results obtained when the respective heating elements are exposed to temperatures of approximately 720° C. in air. Thus, a heater element of the Ni-Mo-Fe alloy will have a very substantially longer useful life than a heater element of the Ni-Cr alloy. Further, the thermal expansion coefficient of the Ni-Cr alloy is 19.0×10^{-6} cm./° C., as compared with 14.6×10^{-6} cm./° C. for the Ni-Mo-Fe alloy used in accordance with this invention.

It is also to be noted that, in the case of the Ni-Mo-Fe alloy, the alloying temperature is approximately 1,350° C., and such alloy has a high solubility and requires large amounts of energy for the combining of its constituents, so that the described alloy used for the heater element in accordance with this invention is stable in the range from 700° to 800° C., which represents the temperature range normally used for the heater element **7**. On the other hand, in the case of a heater element formed of a Ni-Cr alloy, there is always the danger that the Cr component will precipitate out of the alloy at such operating temperatures of the heater element.

The metal base **6** of the thermion emitting member **5** may be formed of Ni, and may be welded to the central portion of heater element **7**. As shown particularly on FIG. 7, such base **6** has superposed thereon three successive electron emitting oxide layers **24**, **25** and **26**.

The first layer **24** is composed of a compound of a metal, such as, Ni, Pt, and the like, which has a mechanical affinity for the metal of base **6** and which is difficult to oxidize, and an electron emitting oxide, such as, BaO, SrO or CaO. The second layer **25** which is superposed on the layer **24** is composed primarily of an electron emitting oxide, and the third layer **26** superposed over layer **25** is again composed of a compound of a metal, such as, Ni, Pt and the like, that is difficult to oxidize and an electron emitting oxide.

The first layer **24** is formed by spraying or spreading on metal base **6** a compound solution comprising a powder of Ni or Pt, a powdered alkaline earth metal carbonate, such as, $BaCO_3$, $SrCO_3$ or $CaCO_3$, and an adhesive agent, such as, butyl acetate, butyl alcohol, nitrocellulose and the like. The spraying of the compound solution onto metal base **6** can be effected with a conventional spray gun while the compound solution is continuously stirred or agitated. The second layer **25** is formed by spraying onto layer **24** a compound solution which includes at least one of the alkaline earth metal carbonates and at least one of the adhesive agents mentioned in connection with the compound solution for the layer **24**. The third layer **26** is formed by spraying on top of the layer **25** a compound solution which may be similar to that employed for the layer **24**, that is, a compound solution comprising a powdered metal that is difficult to oxidize, a powdered alkaline earth metal carbonate, and an adhesive agent.

After the layers **24**, **25** and **26** have been successively sprayed onto base **6**, pressure is applied to the surface of the upper layer **26** so as to increase the density of the several layers and further to flatten or make smooth the exposed surface of the upper or outer layer **26** for decreasing the possibility of gas intake. Following such application of pressure to layer **26**, the thermion emitting member **5** is aged by heating at a temperature of around 1000° C. in order to stabilize the activation of resolution and electron emission. Such heating serves to sinter the first layer **24** and third layer **26**, and further serves to convert the alkaline earth metal carbonate in each of the three layers into the corresponding oxide.

The thicknesses of the layers **24**, **25** and **26** are dependent upon the electron emitting properties that may be desired. For example, each of the layers may have a final thickness of approximately 30 microns, in which case, the overall thickness of the electron emitting oxide layers **24**, **25** and **26** will be about 100 microns.

Since the third or upper layer **26** includes a metal which is difficult to oxidize, such metal protects the electron emitting oxide against deterioration by gases such as O_2, CO_2 and the like. Further, the metal that is difficult to oxidize in the outer or third layer **26** increases the physical strength of the exposed surface of member **5** and thereby prevents the electron emitting layers from breaking down under the impact of ions and the like. Since the second layer **25** which underlies the layer **26** is composed primarily of an electron emitting oxide, it can complement or add to the reduced electron emission from the layer **26** and can also supply Ba to the surface of the cathode. Further, the fact that the first layer **24** which is in contact with the metal base **6** includes a metal having an affinity for the metal of such base will prevent the cathode oxide from coming off the metal base under the impact of ions and the like.

Since the outer or third layer **26** and the lowermost or first layer **24** include Ni, Pt or the like, their electrical distance is relatively small. The foreging, coupled with the flattening of the exposed surface of the third or outer layer **26**, as previously described, serves to avoid dispersion of the cathode material by reason of local heating.

When installing the above described electron emitting device **1** in the grid structure **2**, a spacer **28** (FIG. 3) is first inserted in grid structure **2** to bear against end wall **2***a* of the latter. When device **1** is inserted in grid structure **2**, the rims or flanges **12** of insulating member **4** engage, at their edges, against spacer **28** and thereby limit the approach of the surface of the thermion emitting member **5** to end wall **2***a* so as to establish a predetermined distance D therebetween. Finally, a retaining member **27** is inserted in grid structure **2** in back of insulating member **4** and such retaining member **27** is formed with an inwardly directed flange **27***a* engageable with face **4***b* of the insulating member to securely hold the latter against spacer **28** upon the welding of retaining member **27** to side wall **2***b* of the grid structure.

Since the springs **13** and **14** in the electron emitting device **1** in accordance with this invention serve to longitudinally tension heating element **7** and, at the same time, to urge such heating element against ledge surface **11***a*, the resilient or yieldable forces thus applied by the springs to heating element **7** ensure that the latter will aways remain tensioned and positioned by ledge surface **11***a* even when the heating element is thermally expanded or subjected to external impacts or vibrations. Since the heating element **7** is always maintained in a predetermined position against the surface **11***a* of ledge **11**, as described above, the predetermined distance D between the thermion emitting surface of member **5** and the central aperture **3** of the grid **2** remains invariable, and thereby results in an electron emitting device which has a stable cut-off characteristic and a uniform cut-off voltage.

Furthermore, in the device according to this invention, the heating element of ribbon-type configuration is a simple structure which can be easily produced. The small themal capacity of such a heating element results in an electron emitting device which operates with low power consumption and high efficiency, and which reaches its full operating condition after a short heating time.

Although a specific embodiment of the invention has been described herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to that specific embodiment, and that various changes and modifications, such as, the forming of the insulating member **4** with a circular periphery, may be effected therein by one skilled in the art without departing from the spirit or scope of the invention as set forth in the appended claims.

What is claimed is:

1. In an electron emitting device, the combination of an insulating member including a support ledge projecting from a face thereof and having at least opposed portions that are spaced apart laterally in a common plane, an elongated heater element extending across the space between said opposed portions of the ledge and having ends projecting beyond said support ledge, a thermion emitting member on said heater element between said opposed portions of the ledge, two spring members mounted on said insulating member and having ends which are connected to respective ends of said heater element, one of said spring members being resiliently flexible in directions generally parallel to said common plane to longitudinally tension said heater element, and the other of said spring members being resiliently flexible in directions generally normal to said common plane to hold said heater element in contact with said opposed portions of the support ledge.

2. An electron emitting device according to claim 1, in which said ends of the spring members connected to the heater element are offset from said common plane in the direction away from that in which said ledge faces.

3. An electron emitting device according to claim 1, in which said one spring member is substantially inflexible in said directions normal to said common plane, and said other spring member is substantially inflexible in said directions generally parallel to said common plane.

4. An electron emitting device according to claim 3, in which each of said spring members includes a leaf spring portion of rectangular cross-sections, said one spring member is disposed with the major axes of its rectangular cross-sections substantially normal to said common plane, and said other spring member is disposed with said major axes of its rectangular cross-sections substantially parallel to said common plane.

5. An electron emitting device according to claim 1, further comprising a grid member having an end wall with an aperture therein and a side wall extending from the perimeter of said end wall and defining therewith a compartment receiving said insulating member with said support ledge at a predetermined distance from said end wall and with said thermion emitting member aligned with, and spaced a fixed distance from said aperture in the end wall.

6. An electron emitting device according to claim 5, in which said insulating member has an aperture opening at said face thereof, said support ledge is annular and projects from said face around said aperture therein, said heater element extends diametrically across said ledge, and said insulating member has side surfaces extending normal to said face and engageable with said side wall of the grid to locate said face parallel to said end wall.

7. An electron emitting device according to claim 6, in which said insulating member has rim portions projecting from said face adjacent said side surfaces to establish said distance of the support ledge from said end wall.

8. An electron emitting device according to claim 1, in which said thermion emitting member includes a metal base fixed to said heater element intermediate the ends of the latter, and three electron emitting oxide layers superposed on said metal base, the layer closest to said base and the layer farthest from said base containing a metal which resists oxidation in addition to an electron emitting oxide.

9. An electron emitting device according to claim 1, in which said heater element is composed of a Ni-Mo-Fe alloy.

10. An electron emitting device according to claim 1, in which said alloy contains, by weight, 4 to 6% Fe, 25 to 30% Mo, and the balance Ni.

11. An electron emitting device according to claim 1, in which said spring members include leaf spring portions disposed generally parallel to said opposed portions of the support ledge, and the ends of said leaf spring portions remote from said ends connected to said heater element are respectively secured on terminal pins which extend through said insulating member and are fixed therein.

12. An electron emitting device according to claim 11, in which said insulating member has bores extending therethrough in alignment with said ends of the spring members connected to the heater element so that the connection of an end of each spring member to a respective end of the heater element can be effected by spot welding electrodes one of which is extended through the bore aligned with such end of the spring member.

13. A method of assembling an electron emitting device according to claim 1, which includes forming said insulating member with bores extending therethrough in alignment with the ends of said spring members to be connected to said heater element, disposing said heater element against said support ledge so that the ends of the heater element are in overlying relation to the ends of the spring members to be connected thereto, inserting said overlying ends of the heater element and spring member between a pair of welding electrodes one of which is extended through an aligned bore of said insulating member, and spot-welding together said overlying ends by supplying a pulsing current to said electrodes.

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U.S. Cl. X.R.

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